MANUALS

OF

NATURAL HISTORY.

BOTANY.

STRUCTURE AND FUNCTIONS OF PLANTS.

A MANUAL OF BOTANY:

COMPRISING

VEGETABLE ANATOMY AND PHYSIOLOGY,

OR

THE STRUCTURE AND FUNCTIONS OF PLANTS.

BY

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It has appeared to the author of this Manual, that although many excellent treatises on the Structure, Functions, Distribution, and Classification of Plants, have been published in this country, and have contributed to extend among us the knowledge of those most interesting subjects, none of them is precisely fitted for the purpose of affording a concise and yet comprehensive view of the vegetable kingdom, such as might be useful to persons desirous of obtaining correct information at as little expense of time and labour as possible. The writings of Dr Withering, Sir James E. Smith, Sir William Jackson Hooker, Professor Henslow, Professor Lindley, Dr Greville, and other eminent botanists among ourselves, and of the many illustrious cultivators of botanical science in France, Germany, Switzerland, and North America, afford abundant materials for a treatise of the kind required. A practical acquaintance with the subject derived from continued observation, experience obtained by teaching it for several years, and an enthusiastic devotion to the study of natural history in general, together with a taste for methodical arrangement, might enable one to select the most important facts, and to present them in a perspicuous point of view, so as to supply the student with a useful Introduction to the study of Botany. The present treatise contains a condensed account of the Structure and Functions of Plants, or of Vegetable Anatomy, Organography, and Physiology,

together with the modifications of form and texture presented by the organs, and the terms by which they are distinguished. As the latter are of especial importance with reference to the Classification and Description of Plants, subjects to be treated of in another volume, they have been repeated and explained in an Alphabetical Glossary at the end of the treatise. The works which have afforded the author the most important aid are those of Linnæus, De Candolle, Mirbel, Dutrochet, Richard, Smith, Lindley, and Henslow. To these are to be added the excellent Manual of M. Delafosse, and Dr Thomson's Organic Chemistry. The Illustrations used, with the exception of some woodcuts, are those of Smith's Introduction to Botany. The arrangement adopted, which in some parts is similar to that of Professor Henslow, the author can state, from experience in teaching, to be well adapted for communicating a knowledge of the subjects treated of.

The great success of the Manual of Geology, the first of the series, and the favourable reports respecting it which have emanated from many individuals, some of them of the highest rank as Geologists, induce the author of the present volume to hope that it may prove equally acceptable, and not less useful.

It is proposed that the next Manual shall be devoted to the Animal Kingdom. The Classification of Plants, according to the artificial and natural methods, will appear before the commencement of the next botanical season.

EDINBURGH, 28*th July* 1840.

TABLE OF CONTENTS.

INTRODUCTION.

SECTION I.

STRUCTURE OF PLANTS.

SECTION II.

FUNCTIONS OF PLANTS.

INTRODUCTION.

1. BOTANY is the Science which treats of Plants. It is not confined to the Arrangement and Description of these bodies, but embraces all that relates to their Structure, Functions, and Distribution. The name of this science is derived from a Greek word, βοτανη, signifying grass or herbage. As natural bodies are disposed into three great classes, Minerals, Vegetables, and Animals, and as the study of the first of these is named Mineralogy, while that of the last is named Zoology, both Greek compounds signifying the Doctrine of Minerals, and the Doctrine of Animals, so the Doctrine or Study of Plants ought to be named BOTANOLOGY, or PHYTOLOGY, these terms being composed of λογος, logos, doctrine or discourse, and βοτανη, above explained, or φυτον, phyton, a plant or vegetable.

2. Natural bodies or objects may be primarily disposed into two vast series. Some are formed by the aggregation of elementary particles or molecules, determined by the general laws of physics, and, although often symmetrical, are not composed of parts or organs adapted for the performance of functions having reference to the growth, propagation, or preservation of the individuals. Such bodies are therefore named INORGANIC. Others are composed of parts or organs, mutually subservient, and are named ORGANIC BODIES. They are possessed of life, whereas the former are destitute of that property.

They all originate from a minute body, gradually enlarge by receiving into their interior particles from without, reproduce bodies similar to themselves, gradually decrease in vigour, and at length die. These organized bodies are separated into two classes, ANIMALS and PLANTS, the systematic or connected study of all that relates to which constitutes the sciences of Zoology and Botany.

3. In examining animals or vegetables with the view of acquiring a correct knowledge of them, it is not sufficient to take note of their external appearance, inspect their organs in a superficial manner, watch the changes which gradually take place in them, or observe their motions and habits. These changes and actions result from their internal structure, and, before we can understand them aright, we must make ourselves acquainted with that structure. Two sciences, or branches of science, take cognizance of the mechanism and functions of the organs of animals and plants. That which makes reference to the form, structure, and disposition of the organs, is named ANATOMY; while to PHYSIOLOGY belong their functions, or the offices which they perform. We have thus, in Zoology, the distinct but connected branches of ZOOLOGICAL ANATOMY or ZOOTOMY, and ANIMAL PHYSIOLOGY; and in Botany the corresponding departments of VEGETABLE ANATOMY or PHYTOTOMY, and VEGETABLE PHYSIOLOGY. These sciences, when applied to the entire series of animals, or to that of plants, with the view of discovering their similitudes, discrepancies, and relations, of disclosing the modifications of their various organs, the laws which determine the mutual relations of these organs, and the connection between the form, habits, and external circumstances of the objects examined, assume the names of COMPARATIVE ANATOMY and PHYSIOLOGY.

4. Now, in treating of Plants generally, we shall have, in the first place, to examine their various organs, both

externally and internally, and then to discover their functions. These objects being very numerous, and highly diversified in form and colour, it is necessary to arrange them into groups, to describe the species, and assign them distinctive characters and names. Each of these three great divisions of Botany, namely, VEGETABLE ANATOMY or ORGANOGRAPHY, as it is also called, VEGETABLE PHYSIOLOGY, and the CLASSIFICATION OF PLANTS, is composed of several subordinate sections, which it is not necessary here to specify, as the multiplicity of terms used in Botany is apt to bewilder the beginner, who can only, by a slow and gradual progress, render himself familiar with them. From what has been stated in this paragraph, it will appear that by Botany is here meant the Science which examines the structure and form of plants, determines their functions, and describes, distinguishes, names, and arranges them. The distribution of plants over the globe, their uses in the economy of nature, their application to purposes especially subservient to the welfare of the human species, and other circumstances usually enumerated in definitions, may all be referred to the above, although in teaching the elements of the science it may be expedient to treat of them separately.

5. The study of Botany recommends itself in various ways. It may, to some extent, be engaged in by individuals of either sex, and of almost every profession. While Zoology, by the destruction of life, the disgust at first excited by dissection, the difficulty of procuring objects, and the necessity of extended journeys and inurement to fatigue, is, in some of its departments at least, repulsive to females; Botany, by the beauty of its objects, the facility with which they may be procured, and the agreeable images and associations which they call up in the mind, seems peculiarly adapted for them. Although a simple study, when pursued merely so far as to learn the names of plants, it is capable of calling into

action the higher faculties of the intellect. Indeed, natural history in general, if we judge of the difficulty of a subject by the want of success of those who strive to master it, seems to be a far more intellectual pursuit than is generally imagined. How many warriors, statesmen, poets, and novelists, have distinguished themselves by the successful exercise of their talents, compared with the very small number of really eminent naturalists! Greece produced but one great naturalist, Rome none, and Modern Europe, for a hundred warriors, can scarcely shew half a dozen of philosophic zoologists or botanists. Yet, strange as it may seem, every individual is in some respect a naturalist, and plants and animals excite the curiosity even of infants. Would that the study of botany, in particular, were made a subject of elementary instruction; for then the young would find in it an inducement to forego much of the vicious practices in which, through mere idleness, they are prone to engage. No pursuit can be more conducive to health, or, unless indulged in to excess, to mental serenity. But although a familiarity with nature may seem necessarily to render religious sentiments habitual, experience shews us, that piety and proficiency in natural history do not always go together. Still, he who is truly pious will find in the study of botany much to gratify his feelings; and he who is not, may meet with much to excite his admiration of the skill and contrivance displayed in the structure and distribution of plants.

SECTION I.

STRUCTURE OF PLANTS.

CHAPTER I.

GENERAL CHARACTERS OF PLANTS.

NATURE OF PLANTS CONSIDERED GENERALLY. DISTINCTION BETWEEN PLANTS AND ANIMALS. APPARENT MOTILITY OF PLANTS NOT DEPENDENT UPON SENSIBILITY. ANALOGIES OF PLANTS AND ANIMALS.

6. General Idea of Plants.—A Plant or Vegetable may be defined an organized living body, destitute of sensibility and voluntary motion. Such a definition, however, although a better cannot be given, affords no precise idea of the nature of a plant. Such is the diversity among the vegetable productions of the globe, as to form, stature, texture, colour, and other qualities, that the definition applicable to all, excludes the more obvious properties of any of them. An oak, at first sight, seems to bear no resemblance to a mushroom; a palm-tree and a lichen are, in many respects, very dissimilar; a blade of seaweed and a stalk of wheat have little in common. Yet not only are these all plants, but every organized body not belonging to the animal kingdom, whether it shoot up to the height of a hundred feet, or more, or scarcely raise itself a twelfth of an inch from the surface of the earth or rock,—whether its texture be hard, like that of the oak, or soft as jelly,—whether it be divided into num-

berless branches, clothed with thousands of leaves, and adorned with many beautiful and fragrant flowers, or in the total absence of such organs, present not even a determinate form,—is a vegetable, and must not be overlooked in attempting to form a general definition. There is not a single organ that presents itself in every plant: one has no root, another no stem, a third no leaves, a fourth no flowers. To increase our perplexity, some plants seem so nearly allied to some animals, that we can hardly say where the series of vegetables ends, and that of animals commences.

7. Essential Distinction between Plants and Animals.—An animal is a living body possessed of sensibility and voluntary motion. All animals, however, cannot move from one place to another, some being fixed, like plants, to a particular spot. But all animals have a stomach or internal cavity, into which is received matter from without, to be elaborated into a fluid capable of affording nutrition. No plant has such an internal cavity. Again, animals are furnished with a nervous system, and contractile muscular fibres, of which there are no traces in plants. Between an animal of the higher order, such as a horse or a lion, and a vegetable of any order, there can be no difficulty in distinguishing; and, after all, few cases of doubt will occur to the student, even among the tribes that possess fewest of the organs of the more highly developed plants or animals. But, as this seems a favourite subject, it may not be improper to point out the principal differences.

8. Principal Characters of Plants and Animals.—Animals being possessed of sensibility and the power of motion, are enabled to search for and select the substances capable of affording them nourishment; and having introduced them into their alimentary cavity, convert them into a substance containing the elements of their various organs. Their food consists of all kinds of ani-

mal and vegetable substances, for the assimilation of which the digestive organs are greatly modified in the different species. But plants, being always fixed in a particular spot, and thus incapacitated from searching for food, are nourished by the substances which surround them, and imbibe or absorb, by their external surface, the atmospheric air, water, and matters dissolved in them. Having thus little choice, their organs of nutrition present little diversity. As the parts of the animal body cannot preserve a fixed position, while those of the vegetable undergo no perceptible displacement, the motion of the nutritious fluids must, in the former, depend upon internal impulses, while, in the latter, it is excited by causes acting from without, and unconnected with the organization, such as heat, evaporation, and moisture. Although animals and vegetables are formed of the same chemical elements, namely, oxygen, hydrogen, carbon, and nitrogen, the latter substance prevails in animals, while carbon is the principal constituent of plants. Lastly, the organs of sensation and motion being nerves and muscles, vegetables are necessarily destitute of these elementary organs. Consequently, they have no heart, or central organ of circulation,—no vessels resembling arteries, veins, lacteals, or lymphatics.

9. Apparent Motility in some Plants.—Although, in most cases, it is very obvious that plants have no sensation or voluntary motion, yet there are some which seem to form an exception. Thus, the branches and leaves of all plants direct themselves toward the light. Certain plants, at the approach of night, or in gloomy weather, close their leaves and flowers; and there are some, as the Sensitive Plant, that shrink, as it were, on being touched. An American marsh-plant, Venus's Fly-trap, has its leaves terminated by an appendage of two lobes, furnished with long spines on the edges, and in the centre of this appendage a space which secretes a fluid attrac-

tive to flies. Should an insect alight on this space, the lobes instantly close, and the animal squeezed against the sharp points on the secreting disk, is soon put to death. The plant named Sun-dew has its leaves bordered with hairs, the tips of which are often seen covered with a drop of a clear clammy fluid, and which, on being irritated, immediately fall down. If the lower part of the stamens of the common Barberry be touched, they will spring against the pistil or central organ of the flower. But these phenomena differ from the voluntary motion of animals, and are explained on mechanical principles.

10. Analogies of Plants and Animals.—But although plants differ in many respects from animals, they agree in others. Thus both are produced from a germ or egg, increase by the assimilation of foreign matter, attain their full development, propagate their species, decline, lose their vitality, and being reduced to the condition of inorganic matter, become subject to the decomposing influence of the atmospheric agents, and are ultimately dispersed, so that their elementary particles are free to enter into new combinations. Plants, as well as animals, respire air, and have a continual motion of their fluids, which are partly converted into solid matter, and partly dispersed by passing through the pores of the superficial parts. They are equally composed of solids and fluids; and the former are disposed into membranes, cellules, and tubes. These analogies, however, are far from being close, and the organs of plants are not, without great latitude, comparable to those of animals. Opportunities of pointing out affinities will occur, when we treat of the structure and functions of the different parts of vegetables.

RECAPITULATION.

6. Define a Plant. Does a general definition afford a precise idea of the nature of plants? Why does it not? Are some plants extremely unlike others? Are there many organs common to all plants?—7. Define an Animal. Have all animals the faculty of locomotion? Have all a stomach or intestinal cavity? Do many cases ordinarily occur, in which a plant cannot easily be distinguished from an animal?—8. Mention some of the principal characters of animals. What difference is there in the mode of nutrition of plants and animals? Why should the motion of the fluids depend on internal agents in animals, and on external in plants. What differences exist in respect to chemical composition? Have plants nerves and muscles? Are they destitute of a heart and vessels analogous to arteries and veins?—9. Mention some examples of apparent motion in plants. Upon what does it depend?—10. What are some of the analogies between plants and animals?

CHAPTER II.

ELEMENTARY PARTS OF PLANTS.

GENERAL ACCOUNT OF THE ORGANS OF PLANTS. THEIR INTERNAL STRUCTURE. CELLULAR AND VASCULAR TISSUE, WITH THEIR MODIFICATIONS.

11. ORGANS OF PLANTS.—The parts of which a plant is composed are named its ORGANS. Thus, the root, the stem, the leaves, the petals, are organs, that is, parts distinguishable from each other by position, form, structure, and function. These organs are composed of ELEMENTARY PARTS, differing from each other, but so minute as generally to be distinctly visible only with the aid of the microscope. These minute parts are named ELEMENTARY ORGANS, ORGANIC TISSUE, or VEGETABLE TISSUE. The

organs of plants, properly so called, or those visible externally, and forming conspicuous and readily distinguishable parts of plants, are physiologically divided into two kinds, namely those subservient to the development and preservation of the individual, and those which have reference to the continuation of the species.

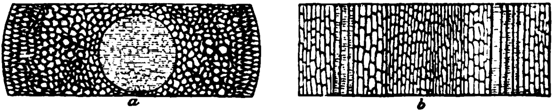
12. Nutritive or Conservative Organs.—The Root, the Stem, the Branches, the Leaves, and some other parts, are those by which the function of nutrition is performed. It is by means of them that the plant imbibes air and moisture, circulates its juices, subjects them to the action of the air, converts them into solid matter, and throws off the superfluous or useless parts. In very many plants, these organs may be arranged into two series, the ascending, and descending, although the distinction is not of much use. The root and its parts, having a tendency to shoot downwards into the earth, belong to the former; while the stem, which shoots upwards, the leaves, flowers, and other parts, are referred to the latter.

13. Reproductive Organs.—The various parts forming the Flower and Fruit, constitute the organs destined for the continuation of the species. The flower includes various parts, an outer envelope named the Calyx, an inner envelope named the Corolla, certain bodies named the Stamens, and a central body named the Pistil. This latter, when fully developed, constitutes the Fruit, which is divisible into several parts. These organs are at present merely alluded to, introductorily to the subject, for the examination of their structure must be preceded by that of the elementary tissue of which they are composed.

14. Internal Structure.—The minute particles of matter of which plants are composed, are combined or united in such a manner as to form two modifications of structure. If we take any common plant, and cut its stem across, we perceive that it is composed of a spongy or cellular mass, denser in some parts, and presenting larger

apertures in others. If we cut the same stem longitudinally, we find the cells assume a different appearance, being elongated, and in some parts like fibres or tubes. Apply-

Fig. 1.



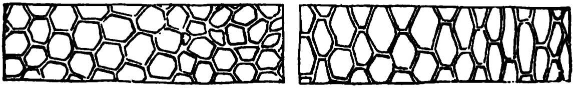
ing the microscope to the transverse section, Fig. 1, *a*, we find its cellules arranged like a network, in the midst of which are the larger openings. In the longitudinal section, Fig. 1, *b*, the network is seen to be formed of more or less elongated cells, while the large apertures seen in the transverse section are found to belong to cylindrical tubes. Different plants will present different appearances, and in some there will be none of those cylindrical fibres or pipes. But the conclusion to which we come is, that plants in general are composed of angular cells and cylindrical tubes, arranged so as to be more or less elongated in the direction of the axis of the stem or other organs. If we examine the cells and tubes more minutely, we find them to be formed of two kinds or modifications of the elementary matter, namely MEMBRANE and FIBRE.

15. MEMBRANE AND FIBRE.—The walls of the internal minute cavities, whether short or elongated, are composed of MEMBRANE, which is extremely thin, colourless, transparent, and generally tears equally in every direction. It is destitute of visible pores or perforations, although, from the passage of liquids through it, we cannot but suppose that apertures of some kind exist in it. FIBRE, as here considered, is not what forms the elongated cells or fibres of plants, but an extremely attenuated form of the elementary substance, which is sometimes straight, but usually spiral, or tortuous. Many observers allege that it is hollow, while others consider it as solid.

Of these two elementary textures, Membrane and Fibre, all the organs of plants are composed. The forms under which they exhibit themselves are :—Cellular Tissue and Vascular Tissue.

16. Cellular Tissue.—The general appearance of the Cellular Tissue may be compared to froth obtained by blowing bubbles in soap-water; but the cellules or vesicles, of which it is composed, assume many forms. The pith of plants is entirely composed of it, but it also enters largely into the structure of the other parts, and in many is the only tissue. It is always transparent and colourless, for, although it presents a vast diversity of colours, and, in fact, is the seat of colour in all parts of plants, this is owing to the colouring matter of various kinds which it contains. This colouring matter is frequently fluid, but often composed of granules adhering to the walls of the cells or immersed in liquid. The most common appearance of the cellular tissue is that of a multitude of spheroidal cellules, rendered more or less angular by being compressed. Frequently in the transverse

Fig. 2.

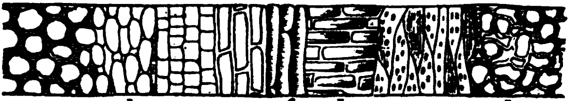


a *b*

section of a plant, Fig. 2, *a*, they seem reticularly hexagonal, and in the longitudinal, *b*, shew that they approach in form to the cells of a honeycomb. Their walls are destitute of visibles pores, but generally allow a transfusion of fluid from one cell to another. Although always very small, the cellules vary exceedingly in dimensions, the largest being in diameter about the 20th part of an inch, the smallest not more than 1000dth. They often leave vacuities between them, which are named Intercellular Passages.

17. Varieties of Cellular Tissue.—Two kinds of Cellular Tissue may be distinguished; the Common, and the Ligneous, the latter being of a denser texture, and composed of more elongated cells. Another division is into Membranous and Fibrous. The Membranous Cellular Tissue, or that in which the walls of the cellules is composed solely of membrane, is the most common kind, and may be considered as the basis of the vegetable structure, it being never wanting in plants, while many are entirely composed of it. The cellules of this variety

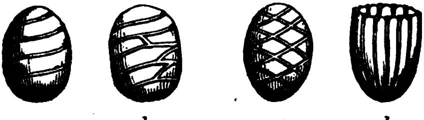
Fig. 3.



a b c e f d g h

may be globular, Fig. 3, *a*; oblong, *b*; cubical, *c*; muriform, or resembling the bricks in a wall, *d*; prismatic, *e*; elongated, *f*; fusiform or spindleshaped and dotted, *g*; or irregular, *h*. The Fibrous Cellular Tissue is of two kinds, being composed either of membrane and fibre combined, or of fibre alone. Of both kinds there are several

Fig. 4.



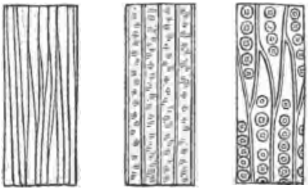
a b c d

modifications, but it will suffice here to mention a few of those of the first. Sometimes an oblong cell, has a fibre spirally twisted round it, Fig. 4, *a*; or the fibre may anastomose irregularly, *b*; or the cell may have a reticulated appearance, produced as it were by two fibres crossing each other, *c*; or the fibres may be longitudinal and parallel, *d*.

18. Woody Cellular Tissue.—This is also named

WOODY FIBRE, it having at one time been supposed to consist of fibres infinitely divisible. It is, however, merely a modification of cellular tissue, in which the cells are much elongated, generally pointed at both ends, and although lying close together in bundles, having no direct communication with each other. This kind of tissue is possessed of great tenacity, and is chiefly that employed in the manufacture of thread and cords, the fibres of flax, hemp, and phormium being composed of it. In the woody parts of plants three varieties have been observed. In one,

Fig. 5.



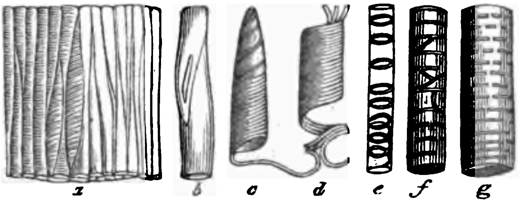
a *b* *c*

Fig. 5, *a*, the walls are even ; in another, *b*, they present adhering to them scattered granules ; and in the third, *c*, the walls have regular series of circular glandules, having an opaque centre. This last kind is peculiar to the trees named Coniferæ, such as the Firs, Pines, and Junipers.

19. VASCULAR TISSUE.—The vessels of plants have little resemblance to the bloodvessels of animals, which are branched and anastomose, or unite with each other. Vegetable Vascular Tissue, on the contrary, is composed of very elongated membranous tubes, tapering at each end, and having a spiral fibre within them, or having their walls marked with broken spiral lines, or dots arranged in a circular or spiral direction, Fig. 6, *a*, *b*, *c*, *d*. The vessels of plants, in fact, might be considered merely as modifications of the common cellular tissue. They are represented by some as having a communicating aper-

ture at their junction, *b*, while others find no pore or perforation in them. Two principal kinds of vessels are distinguished, namely, Spiral Vessels, and Ducts, which, however, shew intermediate gradations.

Fig. 6.



20. Spiral Vessels.—A membranous tube, tapering to a point at each end, and having within it a cylindrical fibre spirally rolled, and capable of being untwisted, is the variety of elementary cellule to which the name of spiral vessel is given, *c*, *d*. From a fancied resemblance in form and function to the windpipe of an animal, it also frequently obtains the name of Trachea. Some have considered this kind of vessel as formed of a fibre spirally twisted, without any membrane, while others state that it is composed of a fibre rolled round or within a cylindrical membrane. The fibre also has been variously represented as cylindrical, or flat, or tubular. A spiral vessel may be formed of a single thread or fibre, *c*, or of two or any number up to twenty, *d*. In the former case, it is said to be simple, in the latter, compound. These vessels are extremely delicate, their diameter averaging the 1000th of an inch. They are very seldom found in the root, bark, or wood, but are frequently abundant in the other parts. They are easily discovered on breaking asunder the leaves and stalks of many plants, when they unroll, and present themselves as delicate filaments like those of spiders.

21. Ducts.—All the varieties of vessels not furnished with an elastic spiral filament are named Ducts. The fact of these vessels being merely elongated cellules is manifested by the analogous ramification of the elementary fibre upon them, giving rise to various appearances; and their being only modifications of the spiral vessels is shewn by some vessels being true tracheæ in one part, and ducts in another, where the spiral fibre has been broken. The following are the principal varieties. When the membranous tube presents at irregular intervals, or in close contact, rings, which seem to be fragments of a ruptured spiral thread, *e*, it is named an Annular Duct. When the spiral fibre is in some parts continuous, in others branched and anastomosing, and sometimes presents the appearance of bars, Fig. 6, *f*, the vessel is named a Reticulated Duct. The Dotted Duct, *g*, is that in which the fibre has been broken into small and nearly equal fragments. Ducts are generally much larger than true spiral vessels, many of them being distinctly visible to the naked eye, and some so large as to admit a hair.

Pl. I., Fig. 1, is a highly magnified representation of the tissue of plants, in a longitudinal section: *a a a*, being cellular texture; *b*, continuous woody fibre; *c*, dotted woody fibre; *d d d*, ducts of various kinds; *e e*, spiral vessels.

Besides these elementary organs, properly so called, there are various cavities resulting from their mode of connection or separation, which require to be here noticed.

22. Vacuities in the Tissue.—As already mentioned, the cellules often leave between them vacuities, to which the name of Intercellular Passages is given, and which always contain a fluid. They vary in size, being larger in succulent plants. Besides these passages, there are often in plants, vacuities or Lacunæ in the tissue, which are bounded by its cellules, and although usually of irre-

gular form, are sometimes very uniform. They have no lining membrane, but do not communicate with the intercellular passages, and contain air, on which account they are appropriately named AIR-CELLS.

23. RECEPTACLES OF PECULIAR JUICES.—Sometimes the intercellular passages are unusually dilated by the fluids which they contain ; or, by the pressure of the latter, cavities are formed in the cellular tissue. Such cavities, filled with the peculiar juices of the plant, are by some named PROPER VESSELS, Receptacles of the Juice, Reservoirs of the proper or peculiar fluids, or Accidental Reservoirs. Although destitute of lining membrane, their walls are generally compact, being formed of condensed cellules. They vary in size and form ; and, although often very regular, sometimes have no definite figure or arrangement.

REMARKS.—Of these modifications of membrane and fibre, are formed all the parts of plants. The varied combinations of the vascular and cellular tissues give rise to an endless variety of structure and external form, and produce an equal diversity in the properties of the juices and secretions. Many plants are entirely composed of cellules, but the greater number of both cellules and vessels. These elementary parts form certain compound organs, which will be described in the next chapter.

RECAPITULATION.

11. What is meant by the term Organ ? Of what are organs composed ? How are the organs divided ?—12. Give an account of the Conservative Organs.—13. What are the Reproductive Organs ?—14. How many kinds of Elementary Structure are there ? What is observed in the transverse and longitudinal sections of a common plant ?—15. What is meant by Membrane ? In what respects is Fibre different ?—16. What

does Cellular Tissue resemble? What are its properties? Describe its general appearance. Are its walls pervious, or porous?—17. How many kinds of cellular tissue are there? Give an account of membranous cellular tissue. Describe the fibrous variety.—18. Of what nature is woody cellular tissue? How many varieties of it are usually described? How are they distinguished?—19. Define Vascular Tissue. What are its two principal kinds?—20. Give a general account of the Spiral Vessels. 21. In what respects do ducts differ? Describe their three varieties.—22. What kinds of vacuities occur in the tissue of plants?—23. What is the nature of the receptacles of the peculiar juices of plants?

CHAPTER III.

GENERAL INTEGUMENT OF PLANTS, AND PARTS CONNECTED WITH IT.

24. EPIDERMIS.—The tissue, or intimate structure, of all plants is composed of the elementary parts briefly described in the preceding chapter; but there are parts more or less complex, which may also be considered as elementary. These are the Cuticle or general envelope of plants, and various organs immediately connected with it.

The EPIDERMIS or CUTICLE is the delicate membrane which invests all the organs of plants. It has been so named on account of its analogy, as to position at least, with the Cuticle or Scarf-skin of animals. Plants, however, have not a true cutis or skin, and their cuticle is in many respects different from that of animals. It presents the appearance of a transparent pellicle, but when examined with the microscope is found to be composed of three distinct parts. The outermost layer is an extremely delicate film, homogeneous in its structure, and perforated by minute oblong pores. Under it is a

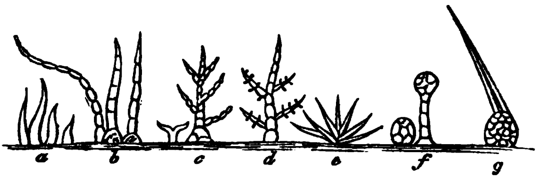
layer of flattened cellules, sometimes arranged in two or three series. The other element of the cuticle consists of the organs named stomata.

25. Stomata.—A Stoma may be defined an aperture in the cuticle, laterally bounded by two generally curved vesicles, Fig. 7. *a*, *b*. Some observers, however, deny the existence of any opening in the stomata, which they consider as cutaneous glands. But the general opinion

Fig. 7.

is that they are pores, which are capable of being closed by the enlargement or elongation of the two cellules forming their sides. They vary in form, being sometimes square, and sometimes oblong or circular. It is commonly supposed that they are subservient to transpiration, and are connected with the reticulated tubes lying in or under the epidermis. In many tribes of flowerless plants, and in the parts of aquatic plants that are under water, they are not met with.

Fig. 8.



26. Hairs.—On the cuticle are observed various prolongations resembling hairs or bristles, which are composed of cellules, generally elongated, and disposed in a single series. Sometimes these hairs are composed each

of a single cellule, Fig. 8, *a*; more frequently of several cellules, *b*; in which case they have the appearance of a tube divided by transverse partitions. They may be branched, *c*, or covered with small processes, which are themselves also sometimes branched, *d*, or they may be divided in a stellular manner, *e*. Hairs are generally acute, *a*, *b*, but often they end obtusely, or are enlarged at the extremity, *f*, and secrete a viscid fluid. In this case they are usually called glandular hairs. A tapering pointed hair having a central canal, and situated on a glandular prominence, is called a sting, *g*; as in the Nettle. Such hairs are analogous to the poison-fangs of serpents. Considered in a general sense, hairs constitute what is called the *Pubescence*, of which various kinds are described. Thus the surface of a plant is said to be

Downy. *Pubescens*. When the hairs are short, delicate, and flexile.

Villous. *Villosus*. When long, straight, and soft.

Pilose. *Pilosus*. When long, scattered, and rather soft.

Hirsute. *Hirsutus*. When rather long, and stiffish.

Tomentose. *Tomentosus*. When longish, soft, entangled, and pressed close to the surface.

Silky. *Sericeus*. When long, very slender, close-pressed, and glistening.

Velvety. *Velutinus*. When short, dense, and soft, forming a surface like velvet.

Arachnoid. *Arachnoideus*. When long, soft, and much entangled, so as to have some resemblance to a spider's web.

Ciliated. *Ciliatus*. When arranged along the margin of an organ, so as to resemble eyelashes.

Bearded. *Barbatus*. When long and placed in tufts.

Bristly. *Setosus*. When conical, short, and stiff.

Hispid. *Hispidus*. When conical, long, and stiff.

Hairs are not found on true roots, nor on any part of

the stem placed under ground, nor on parts immersed in water. They may occur on any other part of the surface of a plant, however, as well as in its cavities.

27. Prickles.—These organs may be considered as complex rigid hairs, Fig. 9. *a*. They are of a conical

Fig. 9.

a *b* *c* *d*

form, straight or curved, and are composed of cellular tissue. Being attached only to the back, they are easily distinguished from spines, which are abortive branches, or prolongations of the woody tissue. Prickles, *Aculei*, occur on all parts of plants, excepting the organs called stamens, but are rarely found elsewhere than on the stem.

28. Scales.—Thin, flat, membranous, scurf-like processes, formed of cellular tissue, are named *Scales*, and differ from hairs chiefly in being more compound, and not of a cylindrical or tapering form, Fig. 9. *b*. This kind of scale is also named *Lepis*, and is to be distinguished from another, which is a kind of rudimentary leaf, *squama*. *Ramenta*, Fig. 9. *c*, are thin, brownish scales, composed entirely of cellular tissue, and distinguished from leaves by the absence of buds in their axillæ. Of this kind are the scales so abundant on the stalks and leaves of Ferns.

29. Glands.—By the term *Gland*, *Glandula*, is designated a small, more or less dense, prominence in the tissue immediately beneath the cuticle, which it causes to project, Fig. 9. *d*. *Warts*, *Verrucæ*, are roundish glandules, filled with opaque matter, which when numerous give the surface a kind of roughness designated by the

term *scabrous*, *scaber*. Glands may be *sessile*, or *stalked*. In the former case, they present the appearance of roundish, conical, or cylindrical bodies ; in the latter, they are roundish bodies, secreting some peculiar fluid, and elevated upon a stalk.

Recapitulation.

24. What is the nature of the Epidermis or Cuticle? Of how many parts is it composed?—25. Describe the Stoma. Is it of general occurrence?—26. What is meant by a Hair? What are the principal varieties of hairs? What is the Pubescence? Mention some of the kinds of surface produced by varieties of pubescence.—27. What are Prickles?—28. Define Scales. What other organs have been so named?—29. What are Glands?

CHAPTER IV.

COMPOUND ORGANS OF PLANTS.

GENERAL VIEW OF THE ARRANGEMENT OF PLANTS FOUNDED UPON THEIR STRUCTURE.

30. Organs of Plants.—The Elementary Organs, the nature of which is disclosed by minute examination, with the aid of the Microscope, combine in various manners to form the parts of plants to which we give the name of Compound Organs, or simply of Organs, and which have already been mentioned as divisible into two kinds, Organs of Nutrition, and Organs of Reproduction. These organs do not all exist in every species of plant, nor in any species do they shew themselves all at once, but are successively developed, and sometimes are transformed into each other. To obtain a general idea of them, it will

therefore be expedient to follow the progress of growth in a common plant, from the period at which the seed begins to germinate, to that at which it produces a seed like itself.

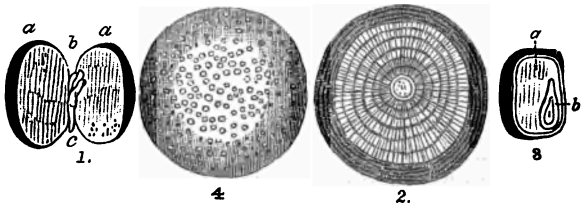
31. RUDIMENTARY ORGANS.—In every seed is contained within the general envelopes a small organized body, which is named the EMBRYO, Pl. I., Fig. 4, *f*, *g*. When germination has commenced, this body swells, bursts the envelopes, and shoots out into two parts, one of which proceeds downwards into the ground, while the other ascends into the air. The descending part, *f*, which is named the *Radicle*, ultimately becomes the *Root*. The ascending part, *g*, the *Plumule* or *Caulicle*, is the rudiment of the *Stem*, leaves, and flowers. The point of junction of the plumule and radicle, is the *Neck* or *Life-knot*, and from it proceed laterally one or more appendages, which are named *Cotyledons* or *Seminal Leaves*, Pl. II., Fig. 7, they being in fact parts which become the first leaves of the plant. In this stage those parts may be called rudimentary organs.

32. PERFECTED ORGANS.—When the *Root*, Pl. II., Fig. 7, has attained its full growth, it usually presents a fleshy body, variously branched, and furnished with *Fibrils* or *Radicles*, having at their extremity a small spongy body, by which nourishment is extracted from the soil. The plumule on becoming developed, shoots up into a *Stem*, which subdivides into branches and twigs. The organs connected with it are at first contained in *Buds*. The *Leaves* are flattened expanded organs of a green colour, which absorb nutritious fluids from the atmosphere, and give out such as have become noxious or superfluous. After them appear the *Flowers*, which are complex organs containing the rudiments of new seeds in an inert state, and the parts necessary for fecundating them. When the seminal germs have been vivified, the flower withers, with the exception of the part containing the seeds, which conti-

nues to grow, and constitutes the *Fruit*. Thus, the essential or fundamental organs of plants may be reduced to five, of which three, the Root, the Stem, and the Leaves, being subservient to the growth and preservation of the individual, are named Organs of Nutrition; while the remaining two, the Flower and the Fruit, being subservient to the continuation of the species, are the Organs of Reproduction. These organs come now to be examined in succession; but preparatorily to their inspection, it becomes expedient to enter into a short exposition of some circumstances, which must frequently be alluded to in the course of our descriptions.

33. General Idea of Classification.—All the *individual plants* that correspond with each other in all their parts, and have been derived from one common stock, constitute SPECIES. Species agreeing closely together in their more important features form GENERA. The genera are variously grouped into TRIBES, FAMILIES, and ORDERS; but all these groups ultimately arrange themselves into three comprehensive groups, named *Dicotyledones*, *Monocotyledones*, and *Acotyledones*.

Fig. 10.



34. Characters of Dicotyledones.—The seeds of this great class of plants are composed of two fleshy bodies, named *Cotyledons*, Fig. 10, 1, *a a*, and the *Embryo*, *b c*, or essential rudiment of the future plant, already described. It is the circumstance of there being *two* cotyle-

dons that gives name to the group. The stem also presents peculiarities, by which it may be easily distinguished, Fig. 10, 2. When young, it has in the centre a cylindrical mass of cellular tissue, named the *Pith*. This is surrounded by a layer of vascular tissue, named the *Medullary Sheath*. The external part or envelope is the *Epidermis*. Between the medullary sheath and the epidermis is formed a mass of vascular and cellular tissue, which at length separates into two parts, the inner forming a layer of *Wood*, the outer a layer of *Bark*. At the end of the second year, between the wood and the bark is found a new double layer of wood and bark. In the third year, there are three layers of wood, and three layers of bark; and in this manner the stem increases in thickness, year after year. In a transverse section of such a stem there are seen the central pith, several concentric rings of wood, an equal number of thinner and usually confused layers of bark, together with bands of cellular tissue radiating from the pith to the bark, and named *Medullary Rays*. The existence of two cotyledons in the seed, of successive layers of wood and bark, and of medullary rays, characterize this class of plants, which are also named *Exogenous*, from the circumstance of their stems enlarging by the apposition of new layers of wood *externally* to those already formed.

35. CHARACTER OF MONOCOTYLÈDONES.—In this class, the seed, Fig. 10, 3, is chiefly composed of a mass of albuminous matter, *a*, inclosing the embryo, *b*, which, in germinating, pushes upward, and ultimately perforates the *single* conical cotyledon. In the stem, Fig. 10, 4, there is no distinction of parts into pith, wood, and bark, it being a cylindrical mass of cellular tissue, in which are dispersed bundles of vessels. The addition of new matter is made towards the centre, and the outer parts are harder than the inner. In consequence of this peculia-

rity in the mode of growth of the stem, these plants are also called *Endogenous*.

36. Characters of Acotyledones.—The plants of which this great class is composed are destitute of seeds, properly so called, and consequently have *no* cotyledons, whence their name. From their not having spiral vessels in their structure, they being formed either of cellular tissue alone, or of cellular tissue and ducts, they are also named *Cellulares*. Their reproductive organs, which are termed *Sporules*, are minute granular bodies, having no distinct parts, but germinating by the increase of cellular tissue. This class is divided into several orders: Ferns, Equisetaceæ, Lycopodiaceæ, Mosses, Hepaticæ, Lichens, Fungi, and Algæ.

The Acotyledones being destitute of flowers, are also named *Flowerless* or *Cryptogamous* Plants; while the Monocotyledones and Dicotyledones, being furnished with these organs, are named *Phanerogamous* or *Phænogamous*. Botany, in fact, is encumbered with superfluous terms.

These preliminary explanations being made, we may now proceed to examine the five principal organs, with their modifications and appendages.

Recapitulation.

30. Of what are the Organs of plants composed?—31. Mention the parts observed in a germinating Seed.—32. What are the five principal organs of a perfect plant?—33. Into what three classes may all plants be arranged?—34. Describe the seed of a Dicotyledonous plant. What parts are observed in its stem? What appearance is presented by a transverse section of it?—35. In what respects do the Monocotyledones differ?—36. What are the general characters of the Acotyledones? What is meant by Exogenous and Endogenous; by Phanerogamous and Cryptogamous?

CHAPTER V.

FORM AND STRUCTURE OF THE ROOT.

37. General Idea of the Root.—The organs of nutrition, or those subservient to the growth and preservation of the individual, are the Root, the Stem, and the Leaves. Those intended for the continuation of the species are the Flower and the Fruit. Many authors divide a plant into two parts, the *Descending Body* and the *Ascending Body*, the former composed of the Root, the latter of the other organs. The Root, Pl. II., Fig. 7, may be defined that part which terminates the plant below, and penetrates into the soil. It thus fixes the plant in a commodious situation, and extracts nutritious matter from the earth for its support. It generally consists of two parts, the *Caudex* or body, and the *Radicles* or fibres. Its upper part, from which spring the stem and the leaves, being frequently narrowed, is named the *Neck*. The radicles are the only essential parts of the root, it being by their usually spongy extremities that moisture is absorbed. Many botanists have considered as roots all those parts of a plant which are immersed in the soil; but, in so doing, they have sometimes confounded the stem with the root. Thus, what they call a creeping root, Pl. II., Fig. 6, as in Mint, is merely a subterranean part of the stem. Although the root is usually fixed in the ground, there are plants which, floating on the water, send out radicles which never reach the bottom; and in tropical countries there are flowering plants which grow upon trees, into the bark of which their roots are inserted.

38. Structure of the Root.—A root of the ordinary kind, in Dicotyledonous plants, consists of cellular and vascular tissue, but without spiral vessels, and, like the

stem, is divisible into a central part, in which, however, are no pith or concentric circles, although there are radiating plates of cellular tissue, named medullary rays; and a cortical part, analogous to the bark. This arrangement may be seen in the Carrot, of which the outer red portion is the bark. The cuticle or epidermis differs from that of the skin in having no stomata. The lower part generally divides into branches, these into subordinate divisions, terminated by small bodies, composed of cellular tissue, without epidermis, and named *Spongioles*. It is remarkable that the root never has a green colour, unless after being for some time exposed to the air.

39. Position of the Root.—Although the root usually terminates the plant below, the stem and branches may, by the application of moisture, and by being kept in the shade, be made to give off roots. As an example of this may be adduced the celebrated Banyan tree of India, the horizontal branches of which send down roots, which, fixing themselves in the ground, are ultimately converted into stems, and, continuing to enlarge, form gigantic props.

40. Duration and Texture.—Some plants continuing only for a single year, or a single season, have *annual* roots. Other plants require two years for their full development, and thus have *biennial* roots. *Perennial*, or lasting roots, are those of woody plants, or of soft plants which die down to the ground annually, but shoot up, year after year, their roots remaining alive. Annual and biennial roots are generally of a soft and more or less succulent texture, as are those of many perennial plants; but the roots of trees and shrubs are, like themselves, hard and woody.

41. Principal kinds of Roots.—There is great diversity in the form of the root; but the principal modifications, or those more commonly observed, are the following.

The *Fibrous Root. Radix fibrosa.* Pl. II., Fig. 5. This kind of root consists of a great number of fibres or filaments, which are sometimes simple or unbranched, at other times variously subdivided. The fibrous root is that seen in monocotyledonous plants, and is commonly considered as that of all annual plants. But in many of these, although slender, it presents exactly the same form and structure as the Tapering Root. The fibres of the roots of most grasses that grow in dry sandy soil are remarkably downy; and those of grasses growing in very moist situations are covered with similar prolongations, though much thicker. In what is called the Creeping Root, Pl. II., Fig. 6, the fibres alone are the roots.

42. The *Tapering Root. Radix fusiformis.* Pl. II., Fig. 7. This root, named also *conical* and *perpendicular*, or *vertical*, is generally fleshy, and of an elongated conical form, either simple, that is, undivided, or branched at its lower extremity. The most common example is afforded by the garden Carrot. In the Radish it is spindle-shaped, or tapering toward both ends. When slender and much branched, as in trees and shrubs, as well as many herbaceous plants, it is usually confounded with the fibrous root, which, however, is peculiar to monocotyledonous plants. By tracing through their gradations the numberless varieties of the cultivated Turnip, it will be seen that its "bulbs" are merely modifications of the conical root. Another remarkable variety is that to which the name of *Radix præmorsa, Abrupt Root*, has been given. Pl. II., Fig. 8. This is, in fact, a tapering root, of which the lower or descending part has decayed, so that it seems as if bitten off. A common example of it is seen in *Scabiosa succisa*, the *Devil's-bit Scabious*, respecting which the old opinion, as expressed by Gerarde, was as follows: "The great part of the root seemeth to be bitten away: old fantastick charmers re-

port, that the divel did bite it for envie, because it is an herbe that hath so many good vertues, and is so beneficial to mankinde."

43. The *Tuberiferous Root. Radix tuberifera.* Pl. II., Fig. 9. Although most roots may be considered as modifications of the Fibrous and Tapering, many present remarkable appendages, and require to be separately considered. Thus, the *Tuberiferous* Root is a fibrous root, to which are attached fleshy or amylaceous knobs or tubers, which, being furnished with buds, are considered as a kind of subterranean stems, and will be afterwards spoken of. A familiar example is the Potato. If the term *Tuber* be appropriated to the potato and similar subterranean productions furnished with buds, it becomes necessary to apply another to those fleshy bodies, which are merely reservoirs of nutritious matter. Professor Lindley proposes naming them *pseudo-tubers*, or false or spurious tubers; but as they are neither tubers, nor yet in any respect spurious, I think they may rather be named Lobes.

44. The *Lobiferous Root. Radix lobifera.* Pl. II., Figs. 10, 11, 12. A fibrous root, having attached to it, or connected with it, one or more masses of cellular tissue, charged with amylaceous matter, and intended as reservoirs for the future development of the plant. Lobes of this kind are seen in Orchideous plants, and are of various forms. Thus, they are *oblong* or *ovate* in *Orchis mascula*, Fig. 10; *palmate*, or shaped like a hand, as in *Orchis latifolia; digitate* or finger-like, as in *Satyrium albidum*. They are extremely numerous and irregularly branched in *Corallorhiza*.

45. The *Bulbiferous Root. Radix bulbifera.* Pl. II., Figs. 14, 15. This is a fibrous root, surmounted by a fleshy body named the *Disk*, which supports a *Bulb*, or peculiar kind of bud, to be afterwards described. It is

only from vaguely considering all subterranean parts as roots, that the bulb, lobe, and tuber, have been mistaken for roots.

46. The *Granuliferous Root. Radix granulifera.* Pl. II., Fig. 16. When a great many small knobs, having an eye or bud, and consisting of fleshy scales, grow in clusters, and are scattered on the fibres of the root, the latter is said to be *granulated, Radix granulata ;* as in a very common plant, *Saxifraga granulata.*

47. VARIETIES OF FORM.—The roots and their appendages exhibit numberless modifications of form, the principal of which may be here enumerated, although some have already been described.

1. *Radix conica.* The *Conical* Root; presenting the form of a reversed cone.

2. *R. fusiformis.* The *Spindle-shaped* Root; tapering toward both ends.

3. *R. napiformis.* The *Top-shaped* Root; as in the Turnip.

4. *R. simplex. Unbranched.*

5. *R. ramosa. Branched.*

6. *R. fibrosa. Fibrous ;* composed of slender filaments, either simple or branched.

7. *R. comosa. Comose ;* with slender filaments, much branched, and very close.

8. *R. capillaris. Capillary ;* when the filaments are so slender as almost to resemble hairs.

The Tubers, Bulbs, or other appendages, may be

1. *Globular. Globosus.* Round like a ball.

2. *Roundish. Subrotundus.* Nearly globular.

3. *Oblong. Oblongus.* With their longitudinal much greater than their transverse diameter.

4. *Didymous. Didymus.* Oblong, and in pairs.

5. *Palmate. Palmatus.* Shaped like the hand.

6. *Digitate. Digitatus.* Resembling fingers, or cleft to the base.

7. *Fasciculate. Fasciculatus.* Composed of a bundle of slender fleshy bodies.

48. Direction of the Root.—The root may be *vertical*, as in the Carrot and Parsnip; *oblique;* or *horizontal.* Frequently all these directions may be found in the same root. The extent to which roots spread depends chiefly on the nature of the soil; but in large trees, the roots being frequently unable to penetrate deeply into the hard subsoil, assume a great lateral extension, their tips often passing far beyond those of the branches. Other circumstances relating to this subject will be mentioned in treating of the physiology of the root. It may be here remarked that *in many plants*, belonging to the Acotyledonous series, the root does not exist as a distinct organ.

Recapitulation.

37. What are the organs of Nutrition? and of Reproduction? Define the Root. What are its parts? Is the root always fixed in the ground?—38. What is the structure of the root in dicotyledonous plants? Is it often green?—39. Does the root always proceed from the base of the stem?—40. How are roots named with reference to their duration?—41. Enumerate the principal varieties of the root. Describe the Fibrous Root.—42. What is a tapering or conical root? What changes of form does it present? What is a præmorse or abrupt root?—43. Why are some roots named tuberiferous? What is a tuber?—44. In what respect does a lobe differ from a tuber?—45. Describe the bulbiferous root?—46. What is meant by granuliferous?—47. What are the terms applied to the principal varieties of form in the root, and its appendages?—48. What are its three principal directions?

CHAPTER VI.

FORM AND STRUCTURE OF THE STEM.

49. General Idea of the Stem.—The Stem may be defined that part of a plant, which, proceeding from the root, either extends under ground, or ascends into the air, and supports the leaves and flowers. Although all Phanerogamous plants, § 36, are furnished with a stem, it is sometimes so short as to seem to be wanting, the leaves and flower-stalks appearing to spring from the top of the root. When this is the case, the plant is said to be *stemless*, *acaulis*. There are some kinds of flower-stalks, namely, the *Scape* and the *Radical Peduncle*, which, being conspicuous, are liable to be confounded with the stem properly so called. On the other hand, there are stems, such as the *Rhizoma* and *Tuber*, §§ 52, 54, which, being subterranean, have been mistaken for roots. These parts will presently be explained. In the mean time, let it be understood that the organ here considered as the stem is the ascending caudex of the plant, or that part to which the leaves, when there are any, are attached.

50. Different kinds of Stems.—The direction, form, texture, consistency, and clothing of stems, produce an almost endless variety in this organ, of which the principal kinds, however, may be reduced to eight. Of these, four are subterranean: the Cormus, Tuber, Rhizoma and Creeping Stem; and four aërial: the Stem, Trunk, Stipe, and Culm.

51. The Cormus.—The *Cormus*, Pl. II, Fig. 13, is the enlarged base of the stem of certain monocotyledonous plants, forming the reproductive portion of such as are destitute of an aërial stem. It is developed under ground, and is of a roundish or oblong form. By many

botanists it has been described as a kind of root, or considered as a solid bulb. It consists of cellular tissue, with bundles of vessels and woody fibre. Examples are seen in the Crocus, Colchicum, and Arum.

52. THE TUBER.—This kind of subterranean stem, often considered as a modification of the root, Pl. II, Fig. 9, may be defined an oblong or roundish body, of annual duration, composed chiefly of cellular tissue, with a great quantity of amylaceous matter, intended for the development of the stems or branches which are to spring from it, and of which the rudiments, in the form of buds, are irregularly distributed over its surface. The Tuber is thus not a root, but a kind of stem. Examples are seen in the Potato and Arrow-root. Nearly allied to it is the organ named the Lobe or Pseudo-tuber, in which there is only a single bud.

53. THE CREEPING STEM.—This kind of stem, *Soboles*, is that which many botanists have named the *Creeping Root*, Pl. II, Fig. 6. It is a subterranean stem, of a slender, elongated form, running nearly horizontally, emitting roots at intervals, and sending up shoots or new plants. The best examples of it are seen among the Grasses and Carices; for example, the Couch-Grass, *Triticum repens*, *Elymus arenarius*, *Triticum junceum*, and *Carex arenaria*, have stems of this kind, which, extending to a great length, and sending up shoots, while their radical fibres are numerous and plentifully furnished with fibrils, serve to bind down the loose sand on the seashore.

54. THE ROOTSTOCK.—The *Rhizoma* or *Rootstock* is a fleshy stem, varying in form, running horizontally under the surface, or partially protruded from it, and sending forth new stems at its anterior or upper extremity, while the other extremity gradually decays. Such a stem is easily distinguished from the root, by its increasing at the part nearest the leaves, and not by its lower end, by

its presenting traces of the leaves of preceding years, and by the appearance of buds upon it. A familiar example is seen in the Iris.

55. The Stem.—Although this is a general term for the ascending caudex, it is applied peculiarly to that kind of aërial stem, *Caulis*, which is of a soft or herbaceous nature, as distinguished from such as are hard or woody. It may be positively defined the ascending part of the plant which bears the leaves and flowers, and negatively that kind which is not a Cormus, Tuber, Creeping Stem, Rootstock, Trunk, Stipe, or Culm. It may vary in its direction from erect to prostrate; in form, from round to angular; in being simple or branched; in having its surface smooth or hairy; and in other circumstances.

56. The Trunk.—The *Trunk*, *Truncus*, is the woody stem of trees and shrubs, such as the Oak, Ash, and Hawthorn; and is peculiar to dicotyledonous plants. It may be described as of an elongated conical form, its diameter being greatest at the base, and gradually becoming less to the top. At its lower part it is to a variable extent destitute of divisions, but towards its upper extremity sends out *branches*, which divide into *twigs*. Internally it is composed of concentric layers, varying in number, and disposed around its axis; and it increases in diameter by the annual addition of a woody layer and a thinner layer of bark, at the part near the surface, where the wood and the bark are in contact. Fig. 10, 2.

57. The Stipe.—The *Stipe*, *Stipes*, is the kind of woody stem peculiar to Monocotyledonous trees, and a few others. When destitute of branches, as it generally is, it presents the appearance of a slender column, being little thicker at the base than toward the top, frequently larger in the middle than elsewhere, and crowned by a tuft of leaves and flowers. Internally it has no appearance of concentric layers, and presents no distinction of wood and bark. It increases in thickness by the addition

of fibres to its interior, and elongates by the development of the bud at its summit: of this kind are the stems of Palms. Fig. 10, 4.

58. THE CULM.—The *Culm* or *Straw, Culmus*, is the kind of stem peculiar to grasses, and plants nearly allied to them. It is generally simple or unbranched, fistulous, or having an internal cavity, and marked at intervals with joints or knots, formed by transverse partitions. The leaves are alternate, and at their base invest the stem with a kind of sheath. The culm, however, may be branched, or solid, or destitute of knots; so that a general character, including all its varieties, is not easily given; and many botanists have thought the distinction superfluous.

59. OTHER VARIETIES OF STEM.—Among the more remarkable kinds of stem not already enumerated, are the *Runner* and the *Sucker*. The former, *Sarmentum*, is a very slender prostrate stem or shoot, Pl. III, Fig. 22, at its extremity producing roots and a young plant, which, in like manner, sends out new runners. The most familiar example is that of the Strawberry. The *Sucker, Surculus*, is a branch which, proceeding from the neck of the root under ground, becomes erect on emerging, and produces leaves, flowers, and branches; as in many Roses. But it is unnecessary to specify all the varieties presented by the stem, and still less to give a name to each.

The principal terms, descriptive of stems in general, are the following:—

60. CONSISTENCE OF STEMS.—Considered with respect to consistence, a stem may be—

1. *Herbaceous. Caulis herbaceus.* Of a soft consistence, or tender, having a green colour, and lasting one year only. Plants having this kind of stem are named *Herbs*, or *Herbaceous Plants.* Such are Chickweed and Groundsel.

2. *Semiligneous. C. suffruticosus.* When the base of the stem is hard and endures for several years, while the extremities of the branches are soft and die annually, such plants are usually named *Under Shrubs*, that term being an erroneous translation of the Latin name, *Suffrutices*, which signifies somewhat shrubby plants. Of this kind are the Common Rue, Sage, and Thyme.

3. *Woody. C. lignosus.* When the stem is of a hard or woody nature, and lasts for many years. Of this kind is the *Trunk*, or stem of dicotyledonous trees, as well as the *Stipe* of most Palms and Ferns, and even the *Culm* of many grasses. Woody plants of the dicotyledonous kind are divided into, *Trees, Arbores*, having a trunk, which is branched only at some considerable distance from the base; and *Shrubs, Frutices*, having the trunk branched from the base. But this division is arbitrary, inasmuch as a particular species, the Box or the Elm, for example, may be either a tree or a shrub, according to the circumstances in which it may be placed.

4. *Solid. C. solidus.* Destitute of internal cavity; as the Oak and Sugar-cane.

5. *Full. C. plenus.* Also without internal cavity, but with the interior pithy; as the Rasp.

6. *Fistulous* or *Hollow. C. fistulosus.* Having an internal cavity, which may be either continuous, or divided by transverse partitions; as in Reeds and Angelica.

7. *Spongy. C. spongiosus.* Internally composed of an elastic cellular tissue, of which the cells are large; as in *Typha.*

8. *Succulent. C. succulentus.* When its interior is composed of cellular tissue of a denser nature, but filled with fluid; as in *Cactus.*

9. *Weak. C. debilis.* When unable to support itself; as in *Anagallis arvensis.*

10. *Stiff. C. rigidus.* Rising directly, and capable of supporting itself with firmness; as in *Rumex crispus.*

11. *Flexile.* *C. flexilis.* Easily bent without breaking; as in the Osier, *Salix viminalis.*

12. *Brittle.* *C. fragilis.* Stiff, but easily broken; as in *Geranium Robertianum.*

61. Division of Stems.—When a stem is destitute of branches, it is said to be *simple, C. simplex;* as in the White Lily. More frequently it is

1. *Branched.* *C. ramosus.*

2. When regularly and repeatedly divided, and having a flower springing from each division, it is called *Dichotomous* or *Forked, C. dichotomus;* as in *Chlora perfoliata,* Pl. II, Fig. 17.

3. *Alternately Branched.* *C. alternè ramosus.* With the branches coming off one after the other.

4. *Two-ranked* or *Distichous.* *C. distichus.* When they spread in two opposite directions; as in the Silver Fir.

5. *Four-ranked* or *Brachiate.* *C. brachiatus.* When they spread in four directions, crossing each other in pairs; as in the Lilac.

6. *Determinately Branched.* *C. determinatè ramosus.* Pl. III, Fig. 23. When each branch, before terminating in a bud or flowers, sends off shoots in a circular form; as in *Erica Tetralix.*

7. *Much Branched.* *C. ramosissimus.* Repeatedly divided into numerous branches, without any definite order; as in the Apple and Gooseberry.

62. Direction of the Stem.—Viewed with respect to its direction or mode of growth, the stem is

1. *Erect* or *Vertical.* *C. erectus.* Growing upright; as in *Lysimachia vulgaris,* and *Rumex obtusifolius.*

2. *Prostrate.* *C. depressus.* Lying flat, and spreading over the ground, without taking root; as in *Malva rotundifolia,* and *Coronopus Ruellii.*

3. *Procumbent.* *C. procumbens.* Lying along the ground, but not so flat as in the last case; as in *Lysimachia nemorum.*

4. *Creeping.* *C. repens.* Lying on the ground, and sending down roots; as in *Lysimachia Nummularia.*

5. *Reclining.* *C. reclinatus.* Ascending at first, and then curved downwards; as in the Bramble.

6. *Ascending.* *C. ascendens.* Rising obliquely, or curved at the base, and then becoming erect; as in Red Clover, *Trifolium pratense.*

7. *Diffuse.* *C. diffusus.* Loosely spreading; as in *Cakile maritima.*

8. *Trailing.* *C. sarmentosus.* As in the Strawberry.

9. *Clinging.* *C. radicans.* Pl. III, Fig. 19. Ascending on another body, and clinging to it by means of fibres; as in the Ivy.

10. *Climbing.* *C. scandens.* Ascending by means of tendrils or claspers; as in the Vine.

11. *Twining.* *C. volubilis.* Pl. III, Fig. 20. Spirally bent round another plant; either to the right, as in the Honeysuckle, or to the left, as in the Kidney Bean.

12. *Flexuous* or *Zigzag.* *C. flexuosus.* Forming angles alternately from right to left, and the reverse; as in *Statice reticulata.*

13. *Tortuous.* *C. tortuosus.* Bent in the same manner, but less angularly; as in *Cakile maritima.*

14. *Straight.* *C. rectus.* In a direct line, whether erect or oblique. *Strictus* signifies the same in the highest degree.

63. FORM OF THE STEM.—The principal varieties of form or shape are the following:—

1. *Round.* *C. teres* or *cylindricus.* Pl. IV, Fig. 32. As in *Caltha palustris.*

2. *Compressed.* *C. compressus.* When slightly flattened on two opposite sides; as in *Poa compressa.*

3. *Two-edged.* *C. anceps.* Round, with two opposite edges.

4. *Three-edged* or *Triangular.* *C. trigonus.* With three sharp angles; as in *Cactus triangularis.*

5. *Three-sided.* *C. triqueter.* When it has three flat sides; as in many species of the genus *Carex.*

6. *Square* or *Four-sided.* *C. tetragonus.* Pl. II, Fig. 6. With four sides; as in *Lamium purpureum.*

7. *Pentagonal.* *C. pentagonus.* With five sides.

8. *Angular.* *C. angulosus.* When the angles or sides exceed five. When the angles become very numerous and small, the grooves thus formed refer more to the surface than to the shape of the stem.

9. *Knotted* or *Nodose.* *C. nodosus.* Presenting knots or enlargements at intervals; as in the basal part of the stem of many grasses, and in *Geranium lucidum.*

10. *Jointed.* *C. articulatus.* Appearing as if having joints at intervals; as in the Mistletoe.

11. *Geniculate* or *Kneed.* *C. geniculatus.* When the joints are angularly bent; as in *Geranium sanguineum* and *Alopecurus geniculatus.*

12. *Wandlike.* *C. virgatus.* Slender, long, straight, and tapering; as in *Althæa officinalis.*

13. *Whiplike.* *C. flagelliformis.* Long, tapering, and supple; as in *Vinca minor.*

14. *Threadlike.* *C. filiformis.* So slender as to resemble a thread; as in *Vaccinium oxycoccos.*

64. CLOTHING OR APPENDAGES.—In most cases the stem and branches are furnished with leaves; but sometimes they are destitute of these organs. In some instances the stem is covered with large scales in place of leaves. These and other circumstances give rise to the following terms:—

1. *Leafy.* *C. foliosus.* Covered with leaves.

2. *Naked* or *Leafless.* *C. nudus* or *aphyllus.* *Cuscuta europæa.*

3. *Scaly*. *C. squamosus*. Bearing scales, or scale-like leaves; as in the genus *Orobanche*. Pl. III, Fig. 18.

4. *Winged*. *C. alatus*. Pl. IV, Fig. 36. When there run down the angles flat leafy borders, which are generally prolongations of the leaves.

65. Surface of the Stem.—Viewed with respect to its surface, the stem presents the following varieties:—

1. *Even*. *C. lævis*. Destitute of all roughness or inequality; as in *Tamus communis*.

2. *Smooth* or *Glabrous*. *C. glaber*. Destitute of hairs, scales, or prickles; as in *Caltha palustris*.

3. *Shining* or *Glossy*. *C. nitidus*. Having the surface polished, so as strongly to reflect the light; as in *Hippuris vulgaris*.

4. *Powdery*. *C. pulverulentus*. Covered with a kind of powder or scurfy substance. The term, *Mealy*, *Farinaceus*, is also employed. *Primula farinosa*.

5. *Glaucous*. *C. glaucus*. When the powder is fine, forms an extremely thin layer, has a sea-green colour, and is easily removed; as in *Chlora perfoliata* and *Pulmonaria maritima*.

6. *Scabrous*. *C. scaber*. Rough to the touch, from little harsh inequalities, the reverse of even; as in *Centaurea nigra*.

7. *Papillate*. *C. papillosus*. Covered with soft tubercles; as in *Mesembryanthemum*.

8. *Warty*. *C. verrucosus*. Presenting small roundish excrescences; as in *Euonymus verrucosus*.

9. *Dotted*. *C. punctatus*. Covered with numerous, somewhat prominent dots; as in *Ruta graveolens*.

10. *Spotted*. *C. maculatus*. Marked with spots of a different colour; as in *Arum maculatum*, *Orchis maculata*, and *Conium maculatum*.

11. *Striated* or *Streaked*. *C. striatus*, Marked with small prominent longitudinal ridges and grooves; as in *Rumex acetosa*.

12. *Grooved* or *Furrowed.* *C. sulcatus.* Marked with deeper grooves and more prominent ridges; as in *Heracleum Sphondyllium.*

13. *Chinky* or *Rifted.* *C. rimosus.* Presenting deep unequal chinks; as in the Elm and many Willows.

14. *Corky.* *C. suberosus.* When the bark is of the nature of Cork, and rifted; as in *Quercus Suber.*

66. Pubescence.—Considered with reference to the hairs on its surface, the stem may be described by employing the terms used at p. 20. It may be Downy, Villous, Pilose, Hirsute, Tomentose, Silky, Velvety, Arachnoid, Ciliated, Bristly, or Hispid. It may also be covered with prickles or thorns; but the latter of these organs are, properly speaking, abortive branches.

These explanations will serve to afford a sufficiently accurate idea of the stem considered as to form and external appearance. We have next to consider its branches.

67. Branches.—The divisions of the stem bear the general name of *Branches, Rami.* They very frequently come off in an irregular manner, and subdivide indefinitely; but sometimes they present a definite arrangement, as already stated. The smaller or terminal divisions are named *Twigs, Ramuli.* With respect to form and surface, they are described in the same manner as the stem, which they generally resemble, although often differing in some particulars.

68. Thorns.—Some twigs, being as it were imperfectly developed, lose their power of extending, assume a hard texture, terminate in a sharp point, and are then named *Thorns, Cuspides.* Sometimes they bear leaves, as in the Sloe and Hawthorn. Some trees, as the Pear and Sloe, which are naturally thorny, on being transplanted into a rich soil, lose their thorns, which, by the abundance of nourishment, are converted into leafy twigs. *Thorns,* Pl. IX, Fig. 120, must not be confounded with *Prickles,* Fig. 121. The former are continuous with the woody

tissue of the plant, while the latter are merely attached to the surface. Thorns, in fact, are modified branches, while prickles are indurated hairs. Nor are they to be confounded with the *Spines*, *Spinæ*, which, as will afterwards be explained, are metamorphosed leaves.

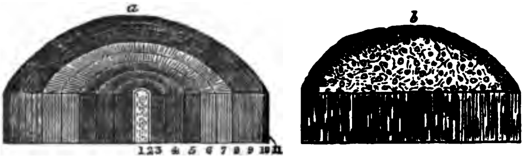
We now proceed to examine the internal or anatomical structure of the stem.

69. INTERNAL STRUCTURE OF THE STEM.—If we take the stem of a herbaceous plant, such as the Field Scorpion-grass, *Myosotis arvensis;* that of a grass, such as the cultivated Wheat, *Triticum hibernum;* that of a common tree, such as the Ash, *Fraxinus excelsior;* and that of a Palm, such as *Corypha umbraculifera;* we find, on examining them, a diversity of structure, which shews that we cannot refer to a single type the modifications which that organ presents. Although a general review of the whole vegetable kingdom, with respect to this subject, cannot be undertaken, it will suffice to afford a general idea of it, that we examine the stem of a tree belonging to the Dicotyledonous, and that of one taken from the Monocotyledonous series. The distinctive characters of these great series have already been briefly given in §§ 34, 35.

70. STEM OF DICOTYLEDONOUS PLANTS.—A transverse section, Fig. 10, 2, p. 24, of the trunk of any of our common trees, an Ash, an Oak, or a Willow, presents two distinct parts, one of which, occupying the interior from the centre to near the circumference, is the WOOD, or WOODY BODY; while the other, the BARK, or CORTICAL BODY, is situated at the exterior, so as to envelope and enclose the wood. Each of these parts, the Wood and the Bark, is composed of two distinct portions, the one fibrous or vascular, the other cellular or parenchymatous. Of the Woody Body, the cellular part occupies the centre, where it forms a cylindrical column, which is named the PITH or *Internal Pith;* while the fibrous part, or WOOD, is arranged in

layers around the pith. In the Bark, on the other hand, the cellular part is placed at the exterior, where it forms a kind of parenchymatous covering to the whole plant, and is what is named the HERBACEOUS ENVELOPE, or *Outer Pith;* while the fibrous part, or the BARK, is placed internally. The Woody Body and the Cortical Body are thus two parts organized in an inverse direction, and which also increase in an inverse direction by annual layers, which are added to the exterior of the wood, but to the interior of the bark.

Fig. 11.



71. ENUMERATION OF THE PARTS OBSERVED.—The above explanation affording only a general idea of the parts composing the stem of a tree, we may now examine them somewhat more closely. In the centre is the *Pith,* Fig. 11, *a,* 1, a cylinder of cellular tissue, surrounded by the *Medullary Sheath,* 2. Proceeding outwards, we count five *Woody Layers,* 3, 4, 5, 6, 7; of which some of the inner, 3, 4, 5, are of a denser texture, and darker colour, than the outer, 6, 7; the former being collectively named the *Duramen* or *Heart-wood,* the latter the *Alburnum* or *Soft Wood.* In the Bark, in like manner, we find five layers, 8, 9, not so easily distinguishable, of which the inner, 8, being softer, are named the *Liber,* or *Inner Bark;* the outer, 9, or harder, the *Cortex,* or *Outer Bark.* Externally of the latter is the *Herbaceous Envelope,* 10, which is cellular, and of a green colour; and, lastly, at the surface of the stem, the *Epidermis* or *Cuticle,* 11. Proceeding from the pith or its sheath, and traversing

the woody layers, in the form of radii, as seen in a transverse section of the stem, are numerous vertical plates of a kind of cellular tissue, usually named *Medullary Rays*. This name, however, being apt to deceive the student, I shall call them, what they really are, *Medullary Plates*. Similar medullary plates, but much less conspicuous, are observed in the bark. Let us now examine these parts in succession, beginning with the outermost.

72. THE EPIDERMIS.—The *Epidermis* or *Cuticle*, already described, § 24, p. 18, as the general integument of plants, is very apparent in young stems or twigs, from which it may be easily separated. As it is constantly distended by the cortical layers, as the stem enlarges in diameter, and has only a certain degree of extensibility, it is torn and destroyed when the trunk has acquired a certain size. This original epidermis must not be confounded with that of old trunks, which is the outer layer of the herbaceous envelope, hardened by contact with the air. This latter kind of epidermis also tears and splits in proportion as the trunk increases in thickness, sometimes dividing longitudinally and sometimes transversely. Sometimes it separates in plates, and is quickly renewed, as is seen in the White Birch, in which numerous layers exist at the same time. The epidermis is often coloured with the juices of the subjacent cellular tissue, but when washed it is transparent and of a greyish-white. It is composed of one or several plates of cellules covered by a delicate membrane, and when young presents the minute apertures named Stomata, §§ 24, 25, which, however, are only found on stems directly exposed to air and light, for the epidermis of stems placed under ground or in water, and that of roots are entirely destitute of them. The surface of the epidermis is also furnished in some dicotyledonous plants with small glands, named *Lenticels;* and is generally or frequently covered with hairs, § 26.

73. THE HERBACEOUS ENVELOPE.—When the epidermis is peeled off, which it may easily be in many twigs, as in the Elder, we find exposed a cellular tissue of a green colour. The reason of its appearing green is because it contains numerous small grains of that colour. It is very succulent, especially in spring, but as it becomes old it assumes a white colour, like the central or inner pith. It is this substance which, being very highly developed, forms the cork of commerce. If the herbaceous envelope be removed, it is reproduced. When old, it splits and tears, like the epidermis, in consequence of being distended by the pressure from within. This part appears to be of great importance, it being in it that the decomposition of the carbonic acid absorbed by the plant takes place.

74. THE BARK OR CORTICAL LAYERS.—On removing the herbaceous tissue, we come to the *Bark*, which is generally formed of a number of layers corresponding to the age of the tree. Every year there is formed a layer of bark, which is produced on the inner surface of the previously formed layer, so that this part increases in thickness by additions from within, while the wood increases by layers added to its surface. The outermost layer of the bark is thus the oldest. Some of those which are most external, having become hard, are distinguished by the name of the *Outer Bark*, or the *Cortical Layers*. Each of them is composed of longitudinal fibres, which are curved, or alternately separate and unite, so as to produce a kind of network. This disposition is very remarkable in some plants, and especially in the Lace-tree, where the cortical layers, on being separated and stretched out, resemble lace, or linen of loose texture. The layers are traversed by medullary rays, proceeding from the herbaceous tissue, and penetrating in the form of pyramids through their meshes.

75. THE LIBER OR INNER BARK.—The innermost part

of the bark, which is named the *Liber*, is composed of a vascular network, of which the elongated meshes are filled with cellular tissue. Its different laminæ are also separated by thin layers of cellular tissue. Like the other parts of the bark, it is capable of being reproduced when it has been removed; but in this case it must be guarded against the contact of air. It is one of the most essential organs of vegetation, and is the seat of the *cambium*, or elaborated juice from which the different parts are produced. The liber is hardened each year, forming a layer of the bark, and by means of the cambium new layers are formed at its inner surface.

76. THE WOODY LAYERS.—Beneath the liber or innermost layer of the bark, we find the *Wood*, composed of the *Alburnum* externally, the *Duramen* or hard wood toward the interior, and the *Pith*. The Alburnum is not essentially different from the hard wood, being merely wood in a young state, not yet fully hardened, and generally of a paler colour. In trees of which the wood is very hard and compact, such as Ebony, Logwood, and Laburnum, there is a very marked distinction as to colour between the wood properly so called, and the Alburnum, the former being much darker; but in trees, of which the wood is soft and white, such as Willows and Pines, there is very little difference in this respect. At the end of some years, the layers of alburnum become converted into wood. This change, however, does not take place with regularity as to time or extent. One part of a layer of alburnum may be seen indurated, while another remains soft; and sometimes a tree is seen to have more layers soft on one side than on another. Once hardened, the woody layers no longer increase in thickness or length, and their vessels generally become impervious to fluids. The wood is composed of elongated cellular tissue, commonly called Woody Fibre, § 18, and is traversed by vessels of the kind named Ducts, § 21. The layer

nearest the central pith is the oldest, and a new layer is formed each year, in contact with the liber or inner bark.

77. THE PITH AND ITS SHEATH.—Within the innermost layer of wood is the *Medullary Sheath* or *Tube*, which is formed of ducts intermixed with spiral vessels. Although generally cylindrical, it presents, in its transverse section, various forms, being angular or elliptical. Once formed, it no longer changes its form or dimensions, but remains the same during the whole life of the plant. The *Pith*, or *Medulla*, is a spongy substance, formed of cellular tissue, and sometimes longitudinally traversed by a few vessels. Its cellules are larger, and more regularly arranged than those of any other part. In herbaceous plants, in young shoots, and woody stems of the first year, it is green and juicy, like the external herbaceous envelope; but, in the progress of vegetation, it loses its fluids and green colour, and is generally found to be dry and white. In some plants which have a rapid growth, it becomes torn, and nearly disappears, leaving the stem hollow.

78. MEDULLARY RAYS.—The thin vertical plates of cellular tissue, which are seen passing from the pith or medullary sheath, through the layers of the wood, are what carpenters call the "silver grain." The beauty of the wood, in fact, depends chiefly upon the manner in which it has been cut, whether perpendicularly to the medullary plates, or so as to divide them obliquely. Although the plates which proceed from the pith run out to the outermost layer of the wood, yet each successive layer of wood shews additional plates originating from or terminating in it; so that, where there may be twenty plates traversing the innermost layer, there may be twenty times that number traversing the outermost.

79. STRUCTURE OF THE MONOCOTYLEDONOUS STEM.—The woody stem of a monocotyledonous plant, Fig. 11, *b*, presents a very different appearance from that of a dicoty-

ledonous tree. This kind of stem is not formed of two bodies, increasing in two opposite directions; and its transverse section shews no circular layers of wood, alburnum, liber, and bark; all these parts seeming, as it were, confounded together in it. The interior of such a stem is composed of cellular tissue, traversed by longitudinal fasciculi of vessels; and its bark is seldom distinguishable from the rest. In the dicotyledonous stem the hardest part is that nearest the centre; but in the monocotyledonous, that nearest the circumference has most solidity. Such is the structure of the stipe in Palms, and that of other families of this class is more or less analogous, although they present differences. Thus, in Bamboos, and grasses generally, the stem is hollow.

80. Structure of the Root similar to that of the Stem.—Reverting to the structure of the root, already described in § 38, it may be remarked, that it generally corresponds to that of the stem. Thus, in dicotyledonous trees, a transverse section shews layers of woody tissue, although not so distinctly defined, and a cortical body, together with medullary plates. The pith, however, is wanting, and there are neither spiral vessels nor stomata. In monocotyledonous trees, the root, instead of tapering, is composed of numerous strings or radicles, issuing from the neck. The root and the stem in all plants form two conical or cylindrical bodies, applied against each other by their bases, and growing by their summits. These bodies branch in opposite directions, the stem dividing upwards, the root downwards.

Recapitulation.

49. What is meant by the stem? Are any phanerogamous plants stemless? What other parts are liable to be mistaken for stems? Are any kinds of stem apt to be considered as

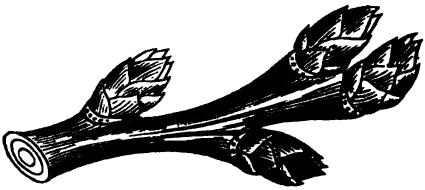
roots ?—50. What are the principal kinds of stem ?—51. Give an account of the Cormus.—52. What is the Tuber ?—53. Define the Creeping Stem.—54. Describe the Rhizoma.—55. What is meant by the stem properly so called ?—56. Describe the Trunk.—57. In what respect is the Stipe different ?—58. What is the nature of the Culm ?—59. Are there any other varieties of the stem ?—60. What are the terms designative of the varieties of the stem considered as to consistence ?—61. What is a simple stem ? What terms are applied to the different modes in which stems branch ?—62. Mention those applied to the varieties of direction in stems.—63. What are the principal varieties of form ?—64. Are all stems furnished with leaves ? What is a winged stem ?—65. What is the difference between smooth and even ? What other terms are applied to the surface ?—66. How is the stem named with respect to its pubescence ?—67. What are the divisions of the stem named.—68. What is the nature of Thorns ? Distinguish between Thorns, Spines, and Prickles ?—69. Does the internal structure differ much in stems ?—70. Of what two bodies are the woody stems of Dicotyledonous plants composed ?—71. Mention all the parts more particularly, commencing at the centre.—72. Give a general account of the Epidermis.—73. What is the nature of the Herbaceous Envelope ?—74. Describe the Bark. Into how many parts is it divided ?—75. What is the nature of the Liber ?—76. Describe the Woody layers. In what respect does the Alburnum differ from the Duramen ? Of what is the wood composed ? Which of its layers is the oldest ?—77. Give an account of the Pith and its Sheath.—78. Describe the Medullary Plates.—79. In what respects is the Monocotyledonous Stem different from the Dicotyledonous ?—80. Has the structure of the Root any relation to that of the stem ?

CHAPTER VII.

BUDS.

81. Nature of Buds.—A Bud, Gemma, is a body composed of the rudiments of some of the various organs of a plant generally inclosed within scales, and placed in the axilla of a leaf, or at the extremity of a twig. Buds may be divided into *subterranean* and *aerial*. According to the organs of which their outer scales are formed, they may be distinguished into:

Fig. 12.



1. *Leafy* or *Foliaceous*. *Gemmæ foliaceæ*. Those of which the scales are leaves that have not been developed; as in Mezereon.
2. *Petiolar*. *G. petiolaceæ*. When the scales are formed by the persistent bases of the leaf-stalks; as in the Walnut.
3. *Stipular*. *G. stipulaceæ*. When enveloped by the stipules; as in the Tulip-tree.

The scales of buds are always abortive organs, which, having served the purpose of protecting them, shrivel and fall off.

82. Composition of Buds.—According to the different shoots to which they give rise, buds are distinguished into three kinds:

1. *Leaf-Buds. G. foliiferæ.* Those which give rise to branches bearing leaves only.

2. *Flower-Buds. G. floriferæ.* Those which produce only flowers.

3. *Mixed Buds. G. mixtæ.* Those which give rise to both leaves and flowers.

Leaf-buds are generally of an ovate or elongated form; flower-buds, roundish; and mixed buds of an intermediate shape. The scales by which buds are enveloped, are frequently covered with resinous or glutinous matter, or with hairs, as if to protect them from the weather. In warm climates, buds are generally destitute of these coverings, and for this reason, among others, the trees of these countries are unable to resist the cold of our winters, and must therefore be sheltered.

83. Arrangement of Buds.—With respect to position, Buds are either regular and symmetrical, or irregular and adventitious. The latter arise accidentally and without order, after the evolution of the stem and leaves, in the roots, in the midst of the wood, on the edges, and on the surface of the leaves. Regular buds, Fig. 12, are found only at the ends of the branches, or in the axils of the leaves. They begin to form in summer, enlarge a little in autumn, remain stationary during winter, and in spring are gradually developed. The uppermost buds of a branch are those which are usually first developed. Buds may be variously disposed, being opposite to each other in pairs, or alternate, or in whorls; and upon this circumstance is dependent the division of the stem into branches. But as many of the buds are never developed, branches are not so symmetrically disposed as leaves.

84. Development of Branches.—Although, owing to various circumstances, such as an unfavourable situation for receiving moisture, air, or light, a bud may not be developed so as to form a branch, it yet generally con-

tinues to live, and being carried outward as the branch enlarges, may, under favourable circumstances, shoot out into a twig. The original direction of the buds determines that of the branches, which may come off from the stem at various angles. Branches may thus be

1. *Adpressed. Rami adpressi.* When they form a very acute angle with the stem, as in the Lombardy Poplar.

2. *Divergent. R. divergentes.* When they come off at an angle of about forty degrees.

3. *Patent* or *Spreading. R. patentes.* When they approach a right angle.

85. SUBTERRANEAN BUDS.—Although the modifications presented by buds, which are developed under the surface of the soil, are numerous, it were useless to designate them all by different names ; and, therefore, it will suffice here to allude to two kinds, the *Turio,* and the *Bulb.*

The *Turio* is the subterranean bud of a perennial herbaceous plant, annually developed, and producing a new stem. Thus, the shoot of the common Asparagus, which is eaten, is a Turio, as are the young shoots of grasses and other plants having a rhizoma or creeping stem.

86. The BULB, *Bulbus,* is a kind of bud belonging especially to certain perennial herbaceous Monocotyledonous Plants. This organ has usually been mistaken for a root ; but the true root connected with it, § 45, consists of a *Disk* or parenchymatous plate, and a number of *fibres* or radicles, generally simple. To the disk are attached numerous fleshy scales, enclosing the rudiments of a stem and leaves. The arrangement of the scales gives rise to two kinds of bulbs :—

1. The *Coated* or *Tunicated Bulb. Bulbus tunicatus.* Pl. II, Fig. 14. When the outer scales, which are thin and membranous, form each a continuous covering ; as in the Onion, Hyacinth, and Daffodil.

2. The *Scaly* or *Squamous Bulb. B. squamosus*. Pl. II, Fig. 15. When the outer scales are distinct, fleshy, and imbricated, like the inner scales; as in the White and Orange Lilies.

Bulbs are generally ovate or globular, and always of annual duration. Sometimes the bulb is *simple*, as in the Tulip; sometimes *multiple*, as in the Garlic. The new bulbs, which are developed in the axils of the bulb-leaves, sometimes arise in the centre of the old bulb, as in the Onion; sometimes by its side, as in the Tulip; or above it, as in *Gladiolus*; or beneath, as in *Ixia*.

87. Bulbils.—There is a kind of bud, which, although not subterranean, but capable of being developed upon different parts of a plant, is in all essential respects similar to the Bulb, and bears the name of *Bulbil, Bulbillus*. It separates spontaneously from the stem, and on being placed in favourable circumstances, gives rise to a new plant. Of this kind are the small knobs seen in the species of Lily named on that account *bulbiferum*, and on some species of Garlic. These bodies are not to be confounded with Seeds, which have a very different structure, as will afterwards be explained.

Recapitulation.

81. Define a Bud. How are buds distinguished according to the organs of which their outer scales are formed?—82. How are they named, with reference to the parts to which they give rise? What is their general form?—83. How are buds arranged upon the stem?—84. Has the direction of the bud any effect upon that of the branches? What terms are applied to the branches with respect to their direction?—85. Are there any subterranean buds? Describe the Turio.—86. Give an account of the Bulb. How many varieties of it are there? Where are the new bulbs formed?—87. In what respects does the Bulbil differ from the bulb?

CHAPTER VIII.

FORM, STRUCTURE, AND RELATIONS OF THE LEAVES.

88. General Idea of the Leaf.—Attached to the sides of the stem are certain appendages, named Leaves, *Folia*, which are organs of respiration and evaporation. They are almost always green, and are composed of vascular fibres, here named *veins* or *nerves*, spread out so as to form a kind of network, of which the interstices are filled with cellular tissue, here termed *parenchyma*, the whole being covered with the epidermis. Although thus generally flat, they are sometimes, in succulent plants, cylindrical or of various forms, presenting the appearance of solid masses. The vessels which, in Dicotyledonous plants, come off from the medullary sheath, being at first close together in bundles, the basal part of the leaf is narrow, and forms what is called the *Petiole*, or Leaf-stalk, *Petiolus*; but they subsequently expand and subdivide, to form the body of the leaf, which is technically named the *Limb*, *Limbus*. These nerves or veins are composed of the same parts as the stem, namely of spiral vessels, ducts, and elongated cellules. In trees, the two surfaces of the leaf differ in structure and functions, the upper surface being generally smoother, firmer, more glossy, and furnished with fewer stomata; while the lower is duller, of a paler tint, and often covered with hairs. In herbaceous plants, the stomata exist equally on both surfaces. Leaves that float on the water, have them only on their upper surface, and those which are entirely immersed, are destitute of them.

89. Situation of Leaves.—Considered with respect to the part of the plant on which they grow, leaves are—

1. *Seminal.* *F. seminalia.* When they are formed by the development of the cotyledonary body. As in Pl. II, Fig. 7.

2. *Primordial.* *F. primordialia.* The first leaves developed after the seminal leaves.

3. *Radical Leaves.* *F. radicalia.* Those which spring from the neck of the root; as in the Cowslip and Dandelion.

4. *Cauline.* *F. caulina.* Those which are attached to the stem.

5. *Branch Leaves.* *F. ramealia.* When they grow on the branches.

6. *Floral Leaves.* *F. floralia.* When placed at the base of the flowers.

90. Disposition of Leaves.—Viewed with reference to their arrangement on the stem and branches, leaves are—

1. *Opposite.* *F. opposita.* Pl. II, Fig. 6. When coming off in pairs, one opposite to the other; as in *Veronica Chamædrys*, Mint, and Sage.

2. *Alternate.* *F. alterna.* Pl. III, Fig. 21. Coming off one by one, from different points; as in the Lime, Elm, and Plane-tree.

3. *Scattered.* *F. sparsa.* Pl. III, Fig. 19. Dispersed without order; as in *Lilium bulbiferum.*

4. *Whorled* or *verticillate.* *F. verticillata.* Pl. X, Fig. 127. Growing in a circle round the stem; as in *Hippuris vulgaris*. When the whorl is composed of three leaves, they are said to be *ternate;* when of four, *quaternate;* of five, *quinate;* of six, *senate;* of seven, *septenate;* of eight, *octonate.*

5. *Geminate.* *F. gemina.* In pairs, one leaf beside the other, and attached to the same point of the stem.

6. *Fasciculate.* *F. fasciculata.* Pl. IV, Fig. 26. More than two together, from the same point; as in the Larch.

7. *Imbricated.* *F. imbricata.* Pl. IV, Fig. 27. So close as partly to be laid over each other; as in common Heath. They may be *biserial*, in two rows; *triserial*, in three; *quadriserial*, in four.

8. *Decussate.* *F. decussata.* In pairs, alternately crossing each other; as in *Veronica decussata.* Pl. IV, Fig. 28.

9. *Distichous.* *F. disticha.* Pl. IV, Fig. 29. Two-ranked, or spreading in two directions; as in the Yew.

10. *Unilateral.* *F. secunda.* Pl. IV, Fig. 30. Leaning toward one side; as *Convallaria multiflora.*

91. Direction of Leaves.—Viewed with respect to direction, they may be:—

1. *Vertical.* *F. verticalia.* Perpendicular; as in *Iris.*

2. *Erect.* *F. erecta.* When forming a very acute angle with the stem; as in *Juncus articulatus.*

3. *Close-pressed.* *F. adpressa.* Pressed close to the stem.

4. *Spreading.* *F. patentia.* Forming a moderately acute angle with the stem.

5. *Horizontal.* *F. horizontalia.* Spreading at right angles.

6. *Reclinate.* *F. reclinata.* Inclining downward.

7. *Recurved.* *F. recurva.* Curved backward.

8. *Incurved.* *F. incurva.* Curved inward.

9. *Pendent.* *F. pendentia.* Directed downwards.

10. *Reversed.* *F. resupinata.* When the petiole is twisted, so that the lower surface is turned upward.

11. *Depressed.* *F. depressa.* Radical leaves pressed close to the ground; as in *Plantago media.*

12. *Floating.* *F. natantia.* Lying on the surface of the water; as in *Nymphæa alba.*

13. *Submersed. F. submersa.* Covered by the water; as in *Hottonia palustris.*

14. *Emersed. F. emersa.* Rising out of the water; as in *Alisma Plantago.*

92. The Petiole.—When the bundle of fibres proceeding from the stem divides and spreads out at once, so as to occupy a portion of the circumference of the stem, and, being flat and of considerable breadth, not to be distinguishable from the lamina or blade, the leaf is said to be *sitting* or *sessile, Folium sessile,* Pl. IV, Fig. 30. But when, on the contrary, the bundle of fibres is prolonged before it expands into a membrane, and thus forms a distinct stalk, the leaf is said to be *petiolate, F. petiolatum,* Pl. III, Figs. 19, 21. Various circumstances relative to the petiole give rise to several varieties of insertion or attachment of the leaves.

93. Insertion of Leaves.—A leaf, whether sessile or petiolate, may be attached to the stem in two different ways. Sometimes the cellular tissue of the leaf is continuous with that of the stem, and sometimes separated from it. In the former case, the leaf, on dying, remains attached to the stem in a withered state. In the latter case, the leaf is affixed by a kind of contraction, at which the fibres are closely united, and the cellular tissue interrupted. Such a contraction is named a *joint* or *articulation,* and the leaf is said to be *articulated.* Leaves so attached are *caducous,* that is, fall off early in winter; and at night they assume a different position from that which they had by day; such leaves occur only in dicotyledonous plants, while the others are chiefly peculiar to monocotyledonous. Sessile leaves present the following modifications.

1. *Semiamplexicaul. F. semiamplexicaule.* When the base of the petiol is expanded, so as to embrace a large portion of the circumference of the stem.

2. *Amplexicaul.* *F. amplexicaule.* Pl. IV, Fig. 32. When it embraces the stem in its whole circumference; as in the Garden Poppy, *Papaver somniferum.*

3. *Sheathing* or *Vaginant.* *F. vaginans.* Pl. IV, Fig. 34. When the petiole, besides embracing the stem, is prolonged, so as to form a sheath to it; as in most Grasses.

4. *Perfoliate.* *F. perfoliatum.* Pl. IV, Fig. 33. When an amplexicaul leaf has its two sides at the base united, so as to appear as if the stem ran through it; as in *Bupleurum rotundifolium.*

5. *Connate Leaves.* *Folia connata.* Pl. III, Fig. 17. When two opposite sessile leaves are united by their bases; as in *Chlora perfoliata* and *Lonicera caprifolium.*

When the petiole is inserted into the middle of the leaf, and the nerves issuing from it spread out in all directions, the leaf is said to be *peltate* or shield-shaped, *F. peltatum*, Pl. IV, Fig. 31; as in *Hydrocotyle vulgaris*, and *Tropæolum majus.*

94. Form of the Petiole.—The Petiole presents other circumstances, which require to be attended to. Thus, it may be *short* or *long.* Viewed with respect to form, it may be *round, compressed, three-sided*, or of some of the forms described in § 63. It may be *club-shaped, P. claviformis*, enlarged at its upper part; *winged, P. alatus*, having the leaf prolonged upon it, so as to form a membranous border on each side, as in the Orange; *leaf-like, P. foliiformis*, when so broad and thin as to have the appearance of a leaf. To this latter kind, which exists in many of the Acacias of New Holland, some have given the name of *Phyllodium.* Very frequently the petiole has a groove along its upper surface, when it is said to be channelled, *P. canaliculatus.*

95. The Limb or Blade.—According to the different dispositions of the nerves, and the manner in which the parenchyma fills up their intervals, the limb or blade of

the leaf assumes a great variety of forms. It will easily be understood, that the form or contour of a leaf is determined by the length to which the nerves or their ramifications extend, and that the entireness or indentation of the margin depends upon the degree in which the parenchyma is developed between them. These circumstances determining the particular form, it is obvious that a distinction into leaves, composed as it were of a single blade, and leaves composed of several pieces, or into simple and compound leaves, is of little real importance. But as this distinction is very obvious, and useful in arranging leaves for description, it may be well to retain it.

96. SIMPLE AND COMPOUND LEAVES.—A *Simple Leaf* is one of which the limb consists of a single piece, Pl. V, of which the margin may be entire, Pl. V, Fig. 38, 39, or variously indented, Fig. 58, 59, and either sessile, Pl. IV, Fig. 30, or petiolate, Pl. II, Fig. 21. A *Compound Leaf*, Pl. VIII, is one composed of several distinct pieces or *leaflets*, each of which is articulated to the petiole, or connected with it by a narrow part, in which the cellular tissue is wanting. For the reason mentioned above, it will be convenient to speak of the Simple and Compound Leaves separately. But previous to this it is of importance to describe the modes of distribution of the nerves.

97. NERVATION OF LEAVES.—By the terms "nervation" and "venation," which are synonimous, is meant the distribution of the vascular fasciculi in the leaf. It is observed that, in monocotyledonous plants, the nerves are generally *simple* and *curved;* and that, in dicotyledonous plants, they are *branched* and *angular*. The degree and manner of branching give rise to several remarkable varieties.

98. CURVINERVED LEAVES.—When the nerves or vascular fasciculi all proceed from the base of the leaf, curve outwards to either side, assume a degree of parallelism,

and traverse the limb in its whole length, the leaf is said to be *curvinerved*, Pl. VII, Fig. 89, 90. The nerves sometimes converge toward the tip, as in the figures referred to, or diverge, as in Pl. V, Fig. 60.

99. ANGULINERVED LEAVES.—In dicotyledonous plants, the nerves, in issuing from the base, separate and form strong veins, Pl. IV, Fig. 31, or run together, so as to form a midrib, from which veins are given off on either side, Pl. VII, Fig. 88, 91. In this kind of leaf the fasciculi subdivide and unite in various degrees, forming a net-work; hence it tears in an irregular manner, while the curvinerved leaf separates, when force is used, in the direction of the nerves, or from the apex to the base. The following varieties of the angulinerved leaf are described.

1. *Penninerved.* Pl. VI., Fig. 80; Pl. VII, Fig. 88. When the *midrib*, or *primary nerve*, extends from the base to the tip, and emits on either side, in its whole length, *secondary* nerves, which subdivide in like manner.

2. *Palminerved.* Pl. VI, Fig. 65. When, instead of forming a midrib, the fasciculi of vessels diverge from the tip of the petiole, forming a number of equally strong nerves, which afterwards subdivide in the penninerved manner.

3. *Pedatinerved.* Pl. VIII, Fig. 114. This is a modification of the last, in which there are three principal nerves, those at the sides sending off large branches in the direction of the tip of the leaf.

4. *Peltinerved.* Pl. IV, Fig. 31. When the fasciculi diverge from the top of the petiole, radiating all round.

100. FIGURE OF SIMPLE LEAVES.—The terms applied to leaves, as designative of the modifications in their outline, margin, apex, and surface, are very numerous. The following are the most important, those expressive of their figure or contour coming first.

1. *Orbicular. Folium orbiculare.* Pl. V, Fig. 38. When the circumference approaches the circular form; as in *Hydrocotyle vulgaris.*

2. *Roundish. F. subrotundum.* Pl. V, Fig. 39. *Pyrola rotundifolia.*

3. *Ovate. F. ovatum.* Pl. V, Fig. 40. Of greater length than breadth, rounded at both ends, with the lower broader; as in Chickweed and the Greater Periwinkle.

4. *Obovate. F. obovatum.* Pl. V, Fig. 41. Of the same figure, but with the broad end uppermost; as in the Primrose and Daisy.

5. *Elliptical. F. ellipticum.* Pl. V, Fig. 42. Elongated, with both ends rounded and equal; as in the Lily of the Valley.

6. *Oblong. F. oblongum.* Three or four times longer than broad.

7. *Spathulate. F. spathulatum.* Pl. V, Fig. 43. Oblong, with the upper end enlarged.

8. *Wedge-shaped. F. cuneiforme.* Pl. V, Fig. 44. Broad and abrupt at the end, and tapering toward the base; as in *Saxifraga cuneifolia.*

9. *Lanceolate. F. lanceolatum.* Pl. V, Fig. 45. Oblong, tapering at either end; as in *Plantago lanceolata.*

10. *Linear. F. lineare.* Pl. V, Fig. 46. Narrow, with the sides parallel; as in the Daffodil.

11. *Needle-shaped. F. acerosum.* Pl. V, Fig. 47. Linear, pointed, and stiff; as in the Fir and Juniper.

12. *Triangular. F. triangulare.* Pl. V, Fig. 48. Having three prominent angles; as in *Chenopodium.*

13. *Quadrangular. F. quadrangulare.* Pl. V, Fig. 49. With four angles; as in *Liriodendron.*

14. *Quinquangular. F. quinquangulare.* Pl. V, Fig. 19. With five angles; as in the Ivy.

15. *Deltoid. F. deltoideum.* Pl. V, Fig. 50. Ha-

ving three angles, of which that at the point is farther from the base than the rest.

16. *Rhomboid.* *F. rhombeum.* Pl. V, Fig. 51. Diamond-shaped; as in *Chenopodium olidum.*

17. *Panduriform.* *F. Panduriforme.* Pl. V, Fig. 57. Fiddle-shaped, or oblong, and contracted in the middle; as in *Rumex pulcher.*

101. Figure with reference to the Base.—Viewed with reference to their base, leaves present the following figures:—

1. *Cordate.* *F. cordatum.* Pl. V, Fig. 53. Ovate, with two rounded lobes at the base; as in *Nymphæa alba.*

2. *Reniform.* *F. reniforme.* Pl. V, Fig. 52. Kidney-shaped, or with the breadth greater than the length, and a wide sinus at the base; as in Ground Ivy and Asarabacca.

3. *Lunulate.* *F. lunulatum.* Pl. V, Fig. 54. Crescent-shaped, or broader than long, and hollowed at the base, with two narrow lobes; as in *Passiflora lunata.*

4. *Sagittate.* *F. sagittatum.* Pl. V, Fig. 55. Triangular, but much hollowed at the base, so that the two lower angles are prolonged and acute; as in *Arum maculatum.*

5. *Hastate.* *F. hastatum.* Pl. V, Fig. 5. Halberd-shaped, triangular, hollowed at the sides and base, with two spreading lobes; as in *Rumex Acetosella.*

102. Figure with reference to the Sides.—The terms here defined are chiefly those which refer to the incisions made as it were into the substances of leaves, strongly affecting their figure, but without regard to minute indentations.

1. *Sinuate.* *F. sinuatum.* Pl. IV, Fig. 32; Pl. V, Fig. 62. Presenting rounded projections and sinuses; as in the Oak.

2. *Lyrate. F. lyratum.* Pl. V, Fig. 59. Sinuate, but with the segments gradually becoming larger toward the end of the leaf, which terminates in a rounded lobe; as in *Erysimum Barbarea.*

3. *Runcinate. F. runcinatum.* Pl. V, Fig. 58. Cut into several lateral, acute segments, pointing backward; as in the Dandelion.

4. *Pinnatifid. F. pinnatifidum.* Pl. VI, Fig. 66. Cut into several lateral oblong, nearly parallel, obtuse segments; as in *Cakile maritima.*

5. *Bipinnatifid. F. bipinnatifidum.* Pl. VI, Fig. 67. When the segments of a pinnatifid leaf are themselves divided in the same manner; as in *Papaver Argemone.*

6. *Pectinate. F. pectinatum.* Pl. VI, Fig. 68. Pinnatifid, with the segments very narrow, and parallel; as in *Hottonia palustris.*

7. *Cleft. F. fissum.* Pl. V, Fig. 60. With narrow divisions of no great depth, and having their margins straight. Leaves of this kind may be two-cleft, *bifida;* three-cleft, *trifida,* &c.

8. *Lobed. F. lobatum.* Pl. V, Fig. 61. When the divisions are deeper, and their margins rounded. They may be two-lobed, *biloba;* three-lobed, *triloba,* &c.

9. *Partite. F. partitum.* Pl. V, Fig. 63. When the divisions extend nearly to the base. Bipartite, *bipartitum;* tripartite, *tripartitum,* &c.

10. *Laciniate. F. laciniatum.* Pl. V, Fig. 64. Deeply cut into numerous irregular portions; as in *Geranium columbinum.*

11. *Palmate. F. palmatum.* Pl. VI, Fig. 65. Cut about half-way to the base, into several oblong, nearly equal segments, leaving a space like the palm of the hand; as in *Ricinus communis,* or *Palma-Christi.*

103. Figure with reference to the Tip.—Viewed

with respect to their distal extremity, apex, or tip, leaves are named as follows :—

1. *Truncate.* *F. truncatum.* Pl. V, Fig. 49. When the extremity seems as if cut off by a transverse line ; as in *Liriodendron tulipifera.*

2. *Premorse.* *F. præmorsum.* Pl. VI, Fig. 70. Very blunt, with irregular notches, as if the tip had been bitten off by an animal ; as in *Epidendrum præmorsum.*

3. *Obtuse.* *F. obtusum.* Pl. V, Fig. 39, 40, 41. Blunt, or terminating in the segment of a circle ; as in the Primrose.

4. *Retuse.* *F. retusum.* Pl. VI, Fig. 71. Ending in a broad shallow notch ; as in *Oxyria reniformis.*

5. *Emarginate.* *F. emarginatum.* Pl. VI, Fig. 72. Notched or nicked, having a small angular notch at the end ; as in *Buxus sempervirens.*

6. *Obcordate.* *F. obcordatum.* Inversely heart-shaped ; as in *Oxalis Acetosella.*

7. *Bifid, Bilobate, Bipartite.* Having the notch at the tip narrow, and extending to a short, moderate, or considerable distance. These terms have been explained.

8. *Acute.* *F. acutum.* Pl. V, Fig. 51. Sharp-pointed, ending in an acute angle ; as in the Lilac and Periwinkle.

9. *Acuminate.* *F. acuminatum.* Pl. V, Fig. 53 ; Pl. VI, Fig. 73. Taper-pointed, running out into a long slender sharp point ; as in *Arundo phragmites.*

10. *Mucronate.* *F. mucronatum.* Pl. VI, Fig. 75. Tipped with a stiff spine ; as in *Ruscus aculeatus.* This is named *Pungent* by some.

11. *Cirrose.* *F. cirrosum.* Pl. VI, Fig. 76. Terminated by a tendril ; as in *Gloriosa superba.*

104. Margins of Leaves.—Considered with respect to its margin, or outline, not taking the larger incisions into consideration, a leaf may be—

1. *Entire.* *F. integerrimum.* Pl. V, Fig. 38, 39, 40, 41. When the margin is continuous, without indentations of any kind; as in the Lilac and Periwinkle.

2. *Repand.* *F. repandum.* Pl. VII, Fig. 84. Wavy, or bordered with alternate small angles and segments of circles; as in *Inula dysenterica.*

3. *Jagged.* *F. erosum.* Pl. VII, Fig. 83. With the margin irregularly cut or notched; as in *Senecio squalidus.*

4. *Toothed.* *F. dentatum.* Pl. VI, Fig. 79. Beset with small projecting teeth, of a substance similar to that of the leaf; as in *Atriplex laciniata.*

5. *Crenate.* *F. crenatum.* Pl. VI, Fig. 81. When the teeth are regular, and not directed toward either end of the leaf; as in *Saxifraga Geum.* A leaf may be doubly crenate; as in *Salvia officinalis* and *Chrysosplenium alternifolium.*

6. *Serrate.* *F. serratum.* Pl. VI, Fig. 80. When the teeth are sharp, and, being directed toward the tip of the leaf, resemble those of a saw; as in the Common Nettle. Leaves may be doubly serrate; as in *Campanula Trachelium* and *Ulmus campestris.* When minutely toothed, they are said to be *serrulate.* Pl. V, Fig. 63.

7. *Spinous.* *F. spinosum.* Pl. VI, Fig. 77. When the margin is beset with spines; as in Thistles.

8. *Fringed.* *F. ciliatum.* Pl. VI, Fig. 78. When margined with soft parallel hairs; as in *Galium cruciatum.*

The margin may be *glandular*, or beset with glands; *revolute*, or rolled backwards; *involute*, or rolled forwards.

105. EXPANSION OF LEAVES.—Viewed with reference to its Expansion, a leaf may be—

1. *Flat.* *F. planum.* As in most plants.

2. *Convex.* *F. convexum.* When convex on its upper and concave on its lower surface.

3. *Concave*. *F. concavum*. When concave on its upper, and convex on its lower surface.

4. *Plaited*. *F. plicatum*. Pl. VII, Fig. 85. When the limb of the leaf is acutely folded in opposite directions; as in *Alchemilla vulgaris*, and in *Malva*.

5. *Undulated*. *F. undulatum*. Pl. VII, Fig. 86. When the limb near the margin is waved; as in *Reseda lutea*.

6. *Rugous*. *F. rugosum*. When the spaces between the veins are convex on the upper, and concave on the lower surface; as in *Salvia*.

7. *Blistery*. *F. bullatum*. Having the above character in a higher degree.

8. *Crisp*. *F. crispum*. Pl. VII, Fig. 87. When the margin of the leaf, being more expanded than the disk, has become curled and twisted; as in *Malva crispa*.

9. *Canaliculate* or *Channelled*. *F. canaliculatum*. Pl. VII, Fig. 97. With a longitudinal concavity or groove along its upper surface.

10. *Carinate* or *Keeled*. *F. carinatum*. With a longitudinal ridge along the back; as in *Narcissus*.

106. CONSISTENCE OF LEAVES.—Considered as to consistence and texture, a leaf may be—

1. *Membranous*. *F. membranaceum*. Of a thin and pliable texture; as in *Rubus odoratus*.

2. *Scarious*. *F. scariosum*. Very thin, dry, and semi-transparent.

3. *Coriaceous* or *Leathery*. *F. coriaceum*. Thick, and of a dense texture; as in the Mistletoe and Laurel.

4. *Fleshy*. *F. carnosum*. Thick and juicy, with considerable firmness; as in *Sempervivum tectorum*.

5. *Stiff*. *F. rigidum*. Hard, and resisting flexion; as in *Ruscus aculeatus*.

6. *Soft*. *F. molle*. Soft to the touch, and easily flexible; as in *Althæa officinalis*.

107. FORM OF LEAVES.—By the *Figure* of leaves is meant the outline or contour of such as are more or less flattened; while *Form*, on the contrary, denotes the bounding of their general surface. A leaf may be—

1. *Flat.* *F. planum.* As in most cases.

2. *Oviform.* *F. oviforme.* Of the form of an egg, or *oboviform*, inversely egg-shaped.

3. *Conical.* *F. conicum.* Having the form of a cone.

4. *Awl-shaped.* *F. subulatum.* Pl. VII, Fig. 95. Of an elongated, conical form, tapering to a point.

5. *Cylindrical.* *F. teres.* Pl. VII, Fig. 93. Much elongated, with the transverse section round.

6. *Semicylindrical.* *F. semicylindraceum.* Pl. VII, Fig. 94. Elongated, flat on one side, round on the other.

7. *Triquetrous.* *F. triquetrum.* Pl. VII, Fig. 99. Having three longitudinal edges; as in *Mesembryanthemum deltoides.*

8. *Tetragonal.* *F. tetragonum.* Pl. VII, Fig. 100. Four-edged; as in *Iris tuberosa.*

9. *Lingulate* or *Tongue-shaped.* *F. lingulatum.* Thick, oblong, and obtuse; as in *Mesembryanthemum linguiforme.*

10. *Tubular* or *Fistulous.* *F. fistulosum.* Cylindrical and hollow; as in the Onion. The leaf of *Lobelia Dortmanna,* Pl. VII, Fig. 96, is formed of a double tube.

11. *Compressed.* *F. compressum.* Pl. VII, Fig. 98. Laterally flattened; as in *Mesembryanthemum uncinatum.*

12. *Sword-shaped* or *Ensiform.* *F. ensiforme.* Laterally flattened, erect, and resembling the blade of a sword; as in *Iris.*

13. *Scimitar-shaped.* *F. acinaciforme.* Compressed, with one edge thick and straight, the other thin and curved; as in *Mesembryanthemum acinaciforme.*

14. *Hatchet-shaped.* *F. dolabriforme.* Pl. VII, Fig. 98. Compressed, with one edge thick and straight, the

other thin, and in part very convex; as in *Mesembryanthemum dolabriforme.*

108. COMPOUND LEAVES.—The modifications hitherto defined are those of the Simple Leaf, or that of which the limb or blade consists of a single piece. The Compound Leaf, or that composed of several distinct pieces, articulated upon a common stalk, presents several varieties. The petiole of such a leaf may be *simple* or *branched.* When it is simple, the leaf is said to be *compound*, properly so speaking; but when it is branched, the leaf is *doubly compound*, or *decompound.* Agreeably to what has been stated with respect to the arrangement of the nerves or veins of the leaf, §§ 97, 98, it is found that they determine the form assumed by compound leaves, which may be divided into those of which the leaflets diverge from the summit of the petiole, or are *palminerved;* and those in which the leaflets come off from the sides of the petiole, or are *pinninerved.* There are other modifications, which, however, may all be referred to these.

109. PALMINERVED COMPOUND LEAVES.—Of the compound leaves, of which the leaflets diverge from the top of the leaf-stalk, the following are the principal varieties:—

1. *Fingered* or *Digitate. F. digitatum.* When several leaflets, their number not being regarded, proceed from the top of the petiole: as in *Trifolium*, where there are three, and in *Æsculus Hippocastanum*, where there are seven. It may even happen that there should be only a single leaflet, and yet the leaf be considered compound, because in other species of the same genus it is clearly so. According to the number of leaflets, this kind of leaf is named—

2. *Ternate. F. ternatum.* Pl. VIII, Fig. 106. A

digitate leaf, having three leaflets ; as in Clover and Wood Sorrel.

3. *Quaternate*, of four leaflets ; as in *Marsilea quadrifolia*. *Quinate*, of five ; as in *Potentilla reptans*. *Septenate*, of seven, as in *Æsculus Hippocastanum*.

4. *Pedate*. *F. pedatum*. Pl. VIII, Fig. 114. A ternate leaf, of which the two lateral leaflets give off others ; as in *Helleborus*.

110. Pinninerved Compound Leaves.—Of the compound leaves, of which the leaflets come off laterally from the petiole, there are several varieties.

1. *Conjugate* or *Unijugate*. *F. unijugatum*. Pl. VIII, Fig. 105. When there is only a pair of leaflets.

2. *Bijugate*. *F. bijugatum*. Of two pairs. *Trijugate, Quadrijugate, Quinquejugate, Multijugate*, of three, four, five, or more pairs.

3. *Oppositely-pinnate*. *F. opposite-pinnatum*. Pl. IX, Fig. 116. When the leaflets come off, one opposite to the other, in pairs ; as in *Rosa*.

4. *Alternately-pinnate*. *F. alterne-pinnatum*. When the leaflets are alternate.

5. *Abruptly-pinnate*. *F. pari-pinnatum*. When the leaflets are in pairs, and the tip of the common stalk either ends abruptly, Pl. VIII, Fig. 101, or in a tendril, Pl. IX, Fig. 115.

6. *Impari-pinnate*. *F. impari-pinnatum*. Pl. VIII, Fig. 108, 110. When the petiole of a pinnate leaf is terminated by a leaflet ; as in *Rosa*.

7. *Interruptedly-pinnate*. *F. interrupte-pinnatum*. Pl. VIII, Fig. 107. Having the leaflets alternately large and small ; as in *Potentilla anserina*.

8. *Lyrately-pinnate*. *F. lyrato-pinnatum*. Pl. VIII, Fig. 108. Having the terminal leaflet much larger than the rest ; as in *Geum rivale*.

9. *Verticillately-pinnate.* *F. verticillato-pinnatum.* Pl. VIII, Fig. 109. When the leaflets are finely divided, and seem to embrace the petiole; as in *Sium verticillatum.*

111. Decompound Leaves.—When the petiole divides into secondary petioles, and these into others, the leaf is said to be *decompound;* and this in various degrees.

1. *Doubly Compound.* *F. decompositum.* Pl. VIII, Fig. 112. When there is a two-fold division of the leaf-stalk.

2. *Thrice Compound.* *F. supradecompositum.* Pl. VIII, Fig. 113. When the division is three-fold.

A leaf may be *Biternate*, Fig. 112, or *Triternate*, Fig. 113; *Bipinnate* or *tripinnate.*

Some circumstances that refer to leaves in general may now be stated.

112. Surface of Leaves.—With regard to the pubescence, or hairs, on the surface of leaves, it will suffice to refer to what has already been said on the subject, § 26; but there are some other circumstances which require to be pointed out. Many of the terms applied to the surface of the stem, § 65, such as *even, smooth, glossy, powdery, watery, spotted,* and *striated,* apply equally to that of the leaves. The following terms may be added:—

1. *Veiny.* *F. venosum.* Pl. VII, Fig. 88. When the vessels are branched, and prominent, forming a network.

2. *Nervous* or *Ribbed.* *F. nervosum* or *costatum.* Pl. VII, Fig. 89. When they extend in undivided longitudinal lines.

3. *Veinless.* *F. avenium; Ribless.* *F. enerve.* Destitute of prominent vessels.

4. *Three-ribbed. F. trinerve.* Pl. VII, Fig. 90. With three distinct ribs from the base to the apex.

5. *Three-ribbed at the base.* Pl. VII, Fig. 91.

6. *Triply-ribbed. F. tripli-nerve.* Pl. VII, Fig. 92. When a pair of large ribs come off from the midrib above the base.

113. Colour and Duration of Leaves.—As has been already mentioned, the colour of leaves is generally green, but of various tints. In the same species the tint varies in the course of its growth and decay. Very frequently the two surfaces of a leaf are of different tints, and sometimes, as in *Cyclamen europæum*, conspicuously so. Sometimes, as in *Arum maculatum*, the leaves are patched or spotted with a darker or lighter colour. Leaves may also be particoloured in irregular masses; but this is generally a result of cultivation.

According to the periods during which leaves remain on the stem, they are named:—

1. *Caducous. F. caduca.* When they fall soon after their development; as in some species of Cactus.

2. *Deciduous. F. decidua.* When they fall before the next spring; as in the Elm and Ash.

3. *Marcescent. F. marcescentia.* When they wither before falling; as in the Oak and Beech.

4. *Persistent. F. persistentia.* When they remain longer than a year; as in Pines.

114. Appendages of Leaves.—Under this head may be included Stipules, Spines, and Tendrils.

The Stipule, Stipula, is a small leaf-like appendage to the leaf. It is commonly situated at the base of the petiole, in pairs, as in Pl. IX, Fig. 116, 122, either adhering to it, or standing separate. They are usually of a more delicate texture than the leaf, but vary in this respect, as well as in form and colour. In describing

them the terms used for the leaf are employed. They are generally considered as analogous to the leaves, or accessory to them, and are sometimes transformed into leaflets. Very few monocotyledonous plants have stipules; and the membranous part at the top of the sheath in grasses, although by many considered as such, seems to be of a different nature.

115. TENDRILS.—The *Tendril, Cirrus*, Pl. IX, Fig. 122, is a prolongation of the petiole into a filiform body, which by clasping objects serves to support plants which have weak stems. Some tendrils, however, as in the Cucumber, are altered stipules; and others, as in the Vine, are transformed branches or flower-stalks.

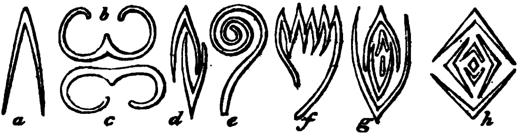
116. SPINES.—The Thorn, which is also named *Spina*, has been already described as an altered branch; but the *spine* here alluded to, is considered as an alteration of the leaf or petiole. The spines which project from the edges of leaves, as in the Holly and Thistles, are clearly seen to be the extremities of the vascular fasciculi; and in the Barberry, the gradual transformation of the leaves into spines may be distinctly traced.

117. THE PITCHER.—A very curious body called the *pitcher*, appears to be a modification of the petiole and leaf, the body of the pitcher being the petiole, and the lid the leaf. When in its most perfect state, as in the pitcher-plant, *Nepenthes destillatoria*, this is not so obvious, and it might be mistaken for a distinct organ, especially as it secretes a fluid. But in *Sarracenia*, Pl. VIII, Fig. 102, and more especially in *Dionœa muscipula*, Fig. 103, the transformation is obvious.

118. VERNATION.—Having described the leaves sufficiently in detail to afford a pretty comprehensive knowledge of them, I may now say a few words respecting the manner in which they are folded up in the bud, previous-

ly to its expansion. This is named *Vernation*, while the folding of the parts of the flower is named *Æstivation*. The principal varieties of the former are the following.

Fig. 18.



1. *Conduplicate.* *Vernatio conduplicativa.* *a.* The leaf folded lengthwise, one-half applied against the other, so that their margins correspond, as in *Philadelphus coronarius.*

2. *Revolute.* *V. revoluta.* *b.* Rolled backwards at the sides; as in Rosemary.

3. *Involute.* *V. involuta.* *c.* Rolled forwards; as in the Apple.

4. *Obvolute.* *V. obvoluta.* *d.* When two conduplicate leaves clasp each other.

5. *Circinate.* *V. circinata.* *e.* Rolled from the tip downwards.

6. *Plicate.* *V. plicata.* *e.* Folded lengthwise in several plaits; as in Alchemilla.

7. *Equitant.* *V. equitans.* *g.* Overlapping each other alternately and entirely; as in Iris.

8. *Imbricate.* *V. imbricata.* *h.* Overlapping each other so that the middle of the outer leaf is opposite to the edges of two inner.

119. General Remarks.—Many of the terms applied to the leaves, are equally applicable to other organs of a similar nature, as the Bractea, Calyx, and Corolla. When a leaf is not precisely of any of the forms described above,

such as *ovate*, but appears intermediate between that and another, such as *lanceolate*, it is defined by combining the two terms, *ovato-lanceolate*. The leaves often gradually pass into the *Bracteæ* or floral leaves, presently to be described. In fact the Leaves, the Bracteæ, and the different parts of the flower, namely, the Sepals, the Petals, the Stamens, and the Ovary, are merely modifications of one and the same organ.

RECAPITULATION.

88. What is the nature of the Leaves? Are they always flat? What is the basal narrow part of the leaf called? What name is given to the expanded part? Of what are the fibres of the leaf composed? What differences do leaves present with respect to their stomata?—89. How are leaves named with respect to their situation on the plant?—90. What circumstances are observed in them with reference to their arrangement?—91. How are they named as to direction?—92. When the petiole is not distinguishable from the limb, what is the leaf said to be? What is a petiolate leaf?—93. What is an articulated leaf? Are any leaves not articulated? What is meant by caducous? What are the principal modifications of sessile leaves? Distinguish between the perfoliate and connate leaves? What is a peltate leaf?—94. Does the petiole vary in length?—or in form? What is a winged petiole? Is the petiole often channelled?—95. What is the limb? Is its form affected by the nerves?—96. Define a simple leaf. What is a compound leaf?—97. What is meant by Nervation?—98. How many kinds of nervation are there? Define a Curvinerved leaf.—99. What is an angulinerved leaf? How many varieties of it are there?—100. What are the principal terms applied to leaves considered as to their figure or contour?—101. How are leaves named with reference to their base?—102. Define a sinuate leaf, lyrate, runcinate, pinnatifid, pectinate, cleft, lobed, partite, laciniate, and palmate?—103.

What terms refer to the apex or tip of the leaf?—104. How are leaves named with reference to their margins?—105. What is meant by convex, concave, plaited, and undulated, wrinkled, channelled, and keeled?—106. Do leaves vary in their consistence?—107. What is meant by Form as distinguished from Figure?—108. Define a Compound Leaf? What are the principal kinds of compound leaves?—109. Mention some varieties of palminerved compound leaves.—110. How many kinds of pinnate leaves are there?—111. What are decompound and supradecompound leaves?—112. What terms apply to the surface of leaves?—113. Are leaves of any other colour than green? Is the duration of leaves various?—114. Give some account of the Stipule.—115. What is the Tendril?—116. How are Spines formed?—117. What is the Pitcher?—118. What is meant by Vernation? Mention some of its principal varieties.

CHAPTER IX.

INFLORESCENCE, OR MODE OF FLOWERING.

120. Arrangement of the Flowers.—The manner in which the flowers are disposed upon the stem is termed the *Inflorescence, Inflorescentia.* Owing to the great diversity of aspect which it gives to plants, and the prominent characters which it affords, it requires especial consideration. Under this head are included the Peduncle or Flower-stalk, the Bracteas or Floral Leaves, and the Inflorescence properly so called.

121. The Peduncle.—The stalk of a flower is named the *Peduncle, Pedunculus,* as the stalk of a leaf is named the *Petiole, Petiolus.* As a leaf which is destitute of petiole is said to be *sessile,* § 92, so is a flower which is directly attached by its base also *sessile, Flos sessilis.* On

the other hand, when it has a stalk, it is named *Pedunculate, Flos pedunculatus.* Like the stalk of the leaf, the peduncle may be simple or branched. In the latter case, each of its ultimate divisions that supports a single flower is termed a *Pedicel, Pedicellus,* and the flowers are said to be *pedicellate, Flores pedicellati.*

122. Position and Relations of the Peduncle.—According to its situation, the flower-stalk is named as follows:—

1. *Radical. Pedunculus radicalis.* When it proceeds from the axil of a radical leaf, § 89; as in the Primrose and Cowslip. The radical peduncle is thus synonimous with the *Scape, Scapus,* of Linnæus, which is defined a kind of stem or stalk that supports one or more flowers, but is destitute of leaves. But some botanists distinguish from the radical peduncle the scape, confining the latter term to the peduncle which arises directly from a radical bud, or from the midst of an assemblage of radical leaves; as in the Hyacinths.

2. *Cauline. P. caulinus.* When it springs directly from the stem.

3. *Rameal. P. rameus.* When it springs from the branches.

4. *Petiolar. P. petiolaris.* When united with the leaf-stalk.

5. *Epiphyllous. P. epiphyllus.* When it springs from the surface of a leaf; as in *Ruscus aculeatus.* Pl. IV, Fig. 37.

6. *Axillar. P. axillaris.* Growing from the axil of a leaf, that is between the stem or branch and the base of the leaf, or its stalk; as in *Anchusa sempervirens.*

7. *Extra-axillar. P. extra-axillaris.* When it arises beside the leaf; as in *Solanum Dulcamara.*

8. *Terminal. P. terminalis.* When it is placed on

the tip of a stem or branch, of which it appears to be the termination; as in *Centaurea Scabiosa.*

Several other terms are applied to the peduncle, according to its relations. Thus, it may be *solitary, P. solitarius*, either single on a plant, as in *Rubus Chamæmorus*, or only one in the same place, as in *Antirrhinum spurium.* When several peduncles grow together, they are said to be *clustered, P. aggregati.* When they are irregularly dispersed over the stem, they are termed *Scattered, P. sparsi.* A peduncle may bear one, two, three, or more flowers, *P. uniflorus, biflorus, triflorus, multiflorus.*

123. The Bractea.—As the stipule is a kind of leafy appendage to the leaf, so the *Bractea* is a kind of leaf connected with the flower, or attached to its stalk. In a general point of view, there is no precise limit between the leaf and the bractea. When the leaves gradually become smaller toward the flowers, without undergoing much alteration of form or colour, they are sometimes named *Floral Leaves.* In general, bracteæ may be distinguished from leaves, by their being placed close to the flower, by their smaller size, different form and colour, and thinner texture. It is very seldom that a plant is destitute of bracteæ, which, however, is the case in those belonging to the natural family of the Cruciferæ, such as the Cabbage and Mustard. As these organs vary in form, colour, and consistence, they are individually described in the same manner as the leaves. Thus, a bractea may be lanceolate, ovate, or oblong, § 100; green, red, or purple; membranous, leafy, petaloid, or woody. The bractea presents several remarkable modifications, which require separate consideration.

124. Modifications of the Bracteæ.—Under this

head are included parts, which by many authors have been considered as belonging to the Flower properly so called. Thus,

1. *The Involucre. Involucrum.* Pl. XI, Fig. 143. When the bracteæ, or floral leaves, are so disposed round one or more flowers, as to form a kind of envelope, they are collectively named an Involucre. Such an envelope may be of three, four, five, or more leaves, and is thus named *triphyllum, tetraphyllum, pentaphyllum, polyphyllum.* In the plants named Compound, such as the Thistle and Dandelion, the involucre is formed of numerous leaves, usually imbricated, which surround the expanded top of the peduncle, here named the *Receptacle* or *Anthophore,* Pl. XII, Fig. 209. In the plants named *Umbellate,* as the Carrot and Hemlock, where the peduncles, of which several come off together, branch in the same manner, the leaflets at the base of the peduncles are named the *Involucre,* while those at the base of the pedicels are named the *Involucels,* Pl. X, Fig. 137, 138.

2. *The Cupule. Cupula.* When the bracteas are disposed close together around the flower, and remain, enlarging until the fruit is mature, as in the Oak, they are collectively named the Cupule, which may be of several kinds. When the bracteas are small and scale-like, they form the cup of the Oak. They may be leafy, as in the Hazel; or of firm texture, and entirely covering the fruit, as in the Beech and Chestnut.

3. *The Spatha.* When the bractea, or involucrum, is very large, membranous, and encloses the flowers previous to expansion, as in *Arum* and *Narcissus,* it is named a *Sheath* or *Spatha,* Pl. XII, Fig. 147.

Many other modifications might be adduced; but it will suffice to mention one of the most remarkable, that which occurs in the Grasses.

125. Bracteæ in the Grasses.—The plants to which

we give the name of Grasses, such as Wheat, Oats, and Rye-Grass, present a peculiar arrangement of the bracteæ, which assume the place of the calyx and corolla. A great diversity of opinion has taken place regarding the nature and nomenclature of these organs. They may, however, be described thus. Pl. XII, Fig. 148. Externally are two opposite, thin bracteæ, one placed a little above the other. Within these are two smaller, also opposite organs of a similar nature, one of them often furnished with an awn, or long rigid and twisted bristle-like body. Within these, at the base of the seed or its germ, are two or three minute, generally fleshy scales. The outer scales, or valves, are by some considered the calyx, the inner as the corolla, and the innermost as nectaries. Others regard the outer as bracteas, the inner as the calyx, and the innermost as the corolla. Others consider all these parts as bracteæ. Professor Lindley names the outer scales *glumæ;* the inner, *paleæ;* and the minute scales, *squamulæ.* Richard names them, *lepicenæ*, *glumæ*, and *paleolæ.*

126. THE INFLORESCENCE.—Leaving the consideration of the Flowers for the next chapter, we have here to describe the manner in which they are arranged. The circumstances of flowers being *solitary*, *terminal*, *lateral*, or *axillar*, will be understood from what has been said of the peduncle, § 122. The principal varieties presented by the arrangement of the flowers upon the stem, or its continuation, are the following :—

1. *The Whorl. Verticillus.* Pl. X, Fig. 127. When the flowers surround the stem ; as in *Hippuris vulgaris.* Many authors include under this head the flowers of the *Labiatæ*, or such plants as the Dead Nettle, Pl. X, Fig. 126. But in this case, the flowers grow in two opposite clusters in the axils of the leaves, and thus do not surround the stem.

127. Simple Modes of Inflorescence.—The following are the kinds that present the most simple arrangement.

2. *The Spike. Spica.* Pl. X, Fig. 129, 130, and 131. When a common unbranched peduncle bears numerous flowers, which are either sessile, or have pedicels so short as to be inconspicuous. Wheat, Barley, Rye, and the Orchises afford examples of this kind of inflorescence, in which the lower flowers are always first developed, and the upper follow in succession. In the spike the flowers may be arranged spirally, or all round, or inclining to one side, or on two opposite sides. In grasses, the divisions of the inflorescence are terminated by *Spikelets, Spiculæ.* Pl. X, Fig. 131.

3. *The Raceme. Racemus.* Pl. X, Fig. 128. When a common unbranched peduncle bears numerous flowers, which are furnished with pedicels; as in *Ribes nigrum*, and *R. rubrum.*

4. *The Capitulum.* Pl. X, Fig. 135. This is merely a very short spike, of which the flowers are placed close together; as in Clover.

5. *The Corymb. Corymbus.* Pl. X, Fig. 132. When in a raceme, or spike, the stalks of the flowers become gradually longer, from the highest to the lowest, so that all the flowers stand on nearly the same level; as in the Wall-flower and Cabbage.

6. *The Catkin. Amentum.* Pl. XI, Fig. 146. When the flowers of a spike have bracteæ in place of the calyx and corolla, and either after flowering or ripening, the whole falls off in a single piece; as in Willows and Alders.

7. *The Spadix.* When the flowers are closely arranged round a fleshy peduncle, and inclosed in a spatha; as in Palms and Arums.

8. *The Anthodium.* When in place of a common stalk, there is a broad convex or flattened surface, on which

numerous sessile flowers are arranged, the whole being inclosed within an involucre, as in the plants named Compositæ, such as the Daisy and Thistle. The flowers, or florets, of the outer circle, which generally differ in form from the rest, and are larger, are named *florets of the ray*, while the others are named *florets of the disk*.

9. *The Sertule. Sertula.* Pl. X, Fig. 136. When from the summit of the peduncle proceed several, generally elongated pedicels, nearly of equal length, each bearing a flower; as in *Allium ursinum*. By many authors this kind of inflorescence is termed a *simple umbel*. But the application of a distinct name to it is censured; although, on the same grounds, the use of raceme and corymb ought to be rejected, these modes of inflorescence being merely modifications of the spike.

128. More Complex Modes of Inflorescence.—The above varieties may be considered as *simple*, while the following are *compound*,—

10. *The Umbel. Umbella.* Pl. X, Fig. 138. When from the summit of the stalk proceed several stalks or rays, of nearly equal length, each of which gives rise to a number of rays, bearing flowers. This is what is called a *Compound Umbel*, and is the general mode of inflorescence in the family of plants named *Umbelliferæ*. In a very few of these plants, however, the umbel is simple, and resembles the sertule above described. The primary rays are collectively named the *Umbel*, the secondary the *Umbellule*; the bracteæ at the base of the former constitute the *Involucre*, and those at the base of the latter, the *Involucel*.

11. *The Panicle. Panicula.* Pl. XI, Fig. 140. This may be considered as a compound Raceme. When the main stalk gives off, instead of single flowers, branches bearing several flowers, and subdividing in various degrees, we have a Panicle; as in the Oat and many other grasses.

12. *The Thyrsus.* Pl. XI, Fig. 141. When a panicle is very dense, and of an oblong or pyramidal form; as in the Lilac, Privet, and Horse-chestnut.

13. *The Cyme. Cyma.* Pl. XI, Fig. 139. When from a single point proceed several branches, each of which subdivides irregularly, bearing numerous flowers, placed nearly on a level; as in the Elder.

14. *The Fascicle. Fasciculus.* Pl. X, Fig. 134. When peduncles variously subdivided into short pedicels, bear numerous flowers collected into a close bundle, and nearly level at the top; as in Sweet-William.

In describing plants, adjectives derived from the above terms are often employed; for example, *Corymbose flowers, Umbellate, Fasciculate, Panicled, Racemose.*

129. General Remarks.—In all the above modifications of the Spike and Umbel, the flowers are developed from below upwards, or from without inwards, the uppermost or central flower being the last to expand. But in the cyme, the central flowers are first developed, and to this mode of inflorescence may be referred the dichotomous stem, in which at each bifurcation is situated a pedicellate flower. In this case it may be said that the stem, in place of bearing flowers on its sides only, and being capable of indefinite prolongation, is terminated by a central flower, having, at the base of its pedicel, bracteæ, usually two in number, which from their axils produce two new branches, each with a terminal flower; and so on indefinitely.

Recapitulation.

120. What is meant by the Inflorescence? What parts are included under this term?—121. What is the stalk of a flower called? May a flower be sessile? When stalked,

what term is applied to it? Is the peduncle ever branched? What is the pedicel?—122. What is a Radical Peduncle? Define the Scape. When a peduncle springs from the stem or branch, how is it named? Mention some of the terms applied to it.—123. What is a Bractea? What is a Floral Leaf? How are bracteæ described? Do they present many modifications? Give an account of the Involucrum. What is a Cupule? Describe the Spatha.—125. In what respects are the flowers of grasses remarkable?—126. What is meant by a Verticil?—127. Define a Spike. In what respect does the Raceme differ from the Spike? What other forms of inflorescence seem to be modifications of the Spike?—128. Define the Umbel. What is a Panicle? In what respect is the Thyrsus different? What is meant by Cyme? Give an example of the Fascicle. Enumerate by name all the varieties of Inflorescence.—129. In what kinds are the lower or outer flowers first expanded? Describe the dichotomous mode of inflorescence.

CHAPTER X.

GENERAL CONSIDERATIONS RESPECTING THE ORGANS OF REPRODUCTION.

130. General Idea of the Flower.—The *Flower*, *Flos*, may be defined that part which is especially subservient to the production of seeds. It is an apparatus composed of the organs of fructification properly so called, and of those by which they are surrounded and protected. Considered with respect to structure, it is an assemblage of several whorls or series of leaves, more or less modified in their form and texture, and situated, in the manner of a bud, at the extremity of the peduncle. In the state in which it presents itself in the more perfect dicotyledonous plants, it is composed of an outer verticil of leaves, the *Calyx;* an inner verticil of a more delicate texture,

the *Corolla;* within this, the *Stamens;* and in the centre, the *Pistil* or *Ovary*, inclosing the *Seeds*. The point of attachment of the flower is named the *Receptacle* or *Torus*.

131. RECEPTACLE OF THE FLOWER.—The summit of the peduncle generally expands in some degree, forming a kind of disk, from which the different parts of the flower arise. This expansion has sometimes the form of a fleshy protuberance, sometimes that of a mere plate, scarcely distinguishable, from which the corolla and stamens arise. This plate may be developed so as to be in some measure prolonged over the outer and inner parts of the flower, and sometimes it becomes thickened into a kind of disk. It may also happen that the peduncle is prolonged in the centre of the different parts of the flower, so as to form an axis around which they are symmetrically placed. Most commonly the flower terminates the peduncle. Previously to entering upon the consideration of the parts of the flower, it is necessary to advert to the bud, of which it is the expansion.

132. FLOWER BUDS.—A careful and comparative examination of the various parts of which the flower is composed, and of the ordinary and accidental changes which they undergo, shews, as Professor Henslow remarks, that these organs are "modifications of a common germ, which may be developed according to circumstances, either in the form of a flower-bud, or of a leaf-bud, adapted in the one case to perform the functions of reproduction, and in the other those of nutrition. Flower-buds ought consequently to make their appearance on similar parts of the stem and branches with the leaf-buds, that is, in the axils of the leaves; and the development of such will present us with analogous phenomena. However different in their external characters, still the various parts of the inflorescence must bear a strong affinity to those of the leafy appendages on the branch."

133. ÆSTIVATION.—As the manner in which the

leaves are disposed within the bud is technically named the *vernation*; so that, in which the parts of the flower are arranged previous to its expansion, is named the *Æstivation* or *Præfloration*. The principal modes in which the corolla, or its parts, the petals, are disposed in the bud, are the following.

1. The petals, or divisions of the corolla, may cover each other laterally by a small portion of their breadth; as in *Rosa* and *Pyrus*. In this case, they are said to be *imbricated*. *Æstivatio imbricativa.*

2. A corolla consisting of one piece may be folded upon itself, or *plaited*. *Æ. plicativa*; as in *Convolvulus.*

3. The petals, or the divisions of the corolla, may be spirally *twisted*. *Æ. torsiva*; as in *Oxalis.*

4. The petals may be *puckered*, or wrinkled. *Æ. corrugativa*; as in the Poppy.

5. They may be placed so as to have their edges in contact, like the valves or pieces of some seed-vessels. *Æ. valvaris.*

6. When there are five petals, two outer, two inner, and one covering the latter by one of its sides, the Æstivation is said to be *quincuncial*. *Æ. quincuncialis*; as in *Dianthus.*

The calyx also may present all the above circumstances, and the stamens may be erect, or bent inwards.

134. Parts of the Flower.—A flower, such as we may suppose complete, or possessed of all the parts that may enter into its composition, is externally formed of two whorls of leaves, constituting what is named the *floral envelope*, or *Perianth*, and internally of other two whorls of organs, which, if not resembling leaves in their form, are yet analogous to them, and constitute the essential parts of the flower, or the *Organs of Fructification.*

1. The outer whorl or envelope, is formed of several pieces named *Sepals*, which are either free, that is dis-

united, or in some degree coherent by their margins. Collectively they bear the name of *Calyx* or Flower-cup. They have much of the aspect and structure of leaves, and are generally green.

2. The next whorl, or second envelope, is formed of several pieces named *Petals*, which are also either free, or united, and are collectively named the *Corolla*. They are generally highly coloured, and of more delicate texture than the sepals, which, however, they often resemble, and into which they are sometimes transformed.

3. The third whorl is composed of the *Stamens*, which are free or united, and usually composed of two parts: an upper essential part, the *Anther*, a membranous bag, in which the *Pollen*, or fecundating powder, is contained, and the *Filament* or stalk. The latter is sometimes foliaceous, and the anther itself is seen to be converted into a petal in the case of what is called a *full flower*, produced by cultivation.

4. The fourth whorl, which is placed in the centre of the flower, is composed of pieces named *Carpels*, collectively called the *Pistil*. These pieces are sometimes free, generally united. A carpel is composed of three parts: a lower, usually of a roundish form, named the *Ovary*, which contains the *ovules* or young seeds; an upper, named the *Stigma*, which receives the pollen at the period of fecundation; and an intermediate part, named the *Style*, which, however, is sometimes wanting. The ovary is usually sessile, but sometimes elevated on a stalk, analogous to the petiole of a leaf. Each carpel may be considered as a leaf folded inwards upon itself, and having its tip prolonged into a style.

It thus appears, that, whether the calyx, corolla, stamens and pistils, are to be considered simply as modified leaves, or as distinct parts, they yet have a very decided analogy to these organs; and the general idea of a uniformity of plan, merely presenting modifications accord-

ing to circumstances, is useful in enabling the student more readily to apprehend and remember the series of organs.

RECAPITULATION.

130. What is the Flower considered as to function and structure? What parts enter into its composition? To what is it attached?—131. What is the Receptacle of the flower? Does it vary in form?—132. Is there a direct analogy between Flower-buds and Leaf-buds?—133. What is meant by Æstivation? Describe some of its varieties.—134. What is the Perianth? What are the Organs of Fructification? Give an account of the four whorls of which a flower is composed.

CHAPTER XI.

THE CALYX.

135. GENERAL IDEA OF THE CALYX.—The *Perianth*, or floral envelope of the stamens and pistils, which are the only essential parts of the flower, may be entirely wanting. When present, it may be *single* or *double*. In the latter case it is composed of two whorls of leaves, which may be distinct, or in various degrees united by the edges. Should the two whorls themselves be united, the perianth may assume the appearance of a Calyx, or that of a Corolla, and thus it might be difficult to say whether it ought to be considered as a united calyx and corolla, or as either of these parts. Many writers say, that when the perianth is single, as in the Tulip and Lily, it ought to be considered as a calyx; others in such a case call it a calyx when thick and more or less green, and a corolla when of delicate texture and highly coloured.

In many cases, as in *Nymphæà*, the calyx and corolla pass so gradually into each other, that a distinction of the parts can hardly be made. Professor Lindley thinks the only just mode of distinguishing the calyx is to consider it in all cases the most exterior verticillate series of the flower, within the bracteæ, of whatever texture or colour it may be. A calyx therefore, he adds, can exist without a corolla; but a corolla cannot exist without a calyx. We may thus define the calyx the outermost integument of the flower, consisting of two or more verticillate leaves, either distinct or united, usually green, and of a coarser texture than the corolla.

136. COMPOSITION OF THE CALYX.—The leaves of which the calyx is composed frequently cohere by their edges. As these leaves are named *Sepals*, such a calyx, consisting of a single piece, is named *monosepalous*, Pl. X, Fig. 126. For this term, however, M. Decandolle substitutes *gamosepalous*, implying that the calyx is composed of several united sepals, and not of one sepal only. It is *polysepalous*, when its leaves or sepals are distinct and separate, as in the Wall-flower, or in *Butomus umbellatus*, Pl. XII, Fig. 128. Sometimes the calyx is united to, or covers, the ovary, in which case it is monosepalous and *superior*. The monosepalous calyx is generally *persistent*, that is, remains until the fruit is ripe. The polysepalous calyx is usually *caducous*, or falls off after the flower expands.

137. MONOSEPALOUS CALYX.—In this kind of calyx are distinguished: The *Tube*, *Tubus*, or lower, generally elongated and narrow part; the *Limb*, *Limbus*, or upper, more or less expanded part; and the *Throat*, *Faux*, the part at which the tube and limb unite. According to the degree of union of its sepals, it may be—

1. *Entire*. *Calyx integer*. When completely united,

so that its limb presents no teeth or notches; as in *Eucalyptus*, Pl. X, Fig. 136.

2. *Toothed.* *C. dentatus.* When its margin presents pointed prominences; as in the Lilac.

3. *Cleft.* *C. fissus.* When the divisions reach nearly to the middle of the calyx; as in *Hyoscyamus.* *Bifid, trifid, quadrifid, quinquefid,* having two, three, four, or five notches or clefts.

4. *Partite.* *C. partitus.* When the divisions reach nearly to the base; as in *Digitalis purpurea.* *Bipartite, tripartite,* &c.

It may have all its parts equal, in which case it is said to be *Regular, C. regularis;* as in *Borago* and *Dianthus.* Or its segments may differ in size and figure, as in *Tropæolum,* when it is called *Irregular, C. irregularis.*

138. Form of Monosepalous Calyx.—According to the form which it assumes, the Calyx is named as follows:—

1. *Tubular.* *C. tubularis.* When narrow, elongated, and with the limb and its divisions erect; as in the Primrose and Pink, Pl. XI, Fig. 142.

2. *Urceolate,* or *Pitcher-shaped.* *C. urceolatus.* Swelled out at the base, with the throat narrowed, and the limb dilated; as in *Rosa,* Pl. IX, Fig. 123.

3. *Inflated.* *C. inflatus.* When thin, blown out as it were like a bladder, and much wider than the corolla; as in *Silene inflata.*

4. *Bell-shaped.* *C. campanulatus.* Having the form of a bell, that is, dilated from the base, with the mouth very wide; as in *Melittis.*

5. *Cup-shaped.* *C. cupuliformis.* Concave, like a cup; as in *Citrus medica* and *Eucalyptus,* Pl. X, Fig. 136.

6. *Compressed.* *C. compressus.* Broad, and flattened on two opposite sides; as in *Pedicularis palustris.*

7. *Angular.* *C. angularis.* With prominent longitudinal angles; as in *Primula vulgaris.*

8. *Grooved.* *C. sulcatus.* With numerous longitudinal ridges and grooves.

9. *Two-lipped.* *C. bilabiatus.* Having its divisions so disposed, as to present an upper and a lower lip; as in Sage.

10. *Spurred.* *C. calcaratus.* Having a prolongation at the base; as in *Tropæolum.*

139. Polysepalous Calyx.—A calyx of this kind may be *disepalous*, composed of two sepals; *trisepalous*, of three; *tetrasepalous*, of four; *pentasepalous*, of five sepals. It may present various forms.

1. *Tubular.* *C. tubularis.* When the sepals are long, erect, and in contact with each other.

2. *Campanulate* or *Bell-shaped.*

3. *Stellate.* *C. stellaris.* Of five sepals, and spreading like a star; as in *Stellaria graminea.*

The sepals themselves are to be individually described in the same manner as the leaves. Thus, they may be *ovate, lanceolate, obtuse, acute, fringed, hairy, smooth,* &c. The segments of the monosepalous calyx are also described in the same manner.

140. The Pappus.—A very curious modification of the Calyx is that to which the name of *Pappus* is given, Pl. XVI, Fig. 204. It is peculiar to plants belonging to the natural family of the *Compositæ*, and is familiarly exemplified in the Thistle, it being the part which crowns the seeds, or rather pericarps, of that plant, and by the aid of which they are conveyed to a distance by the winds. In these plants the ovary is placed below the corolla, and from its summit arises a crown of bristles or scales, which are analogous to the calyx, Pl. XVI, Fig. 210. This kind of calyx is persistent, remaining until the fruit is

matured. It presents several modifications. Thus, it may be *sessile*, or proceeding directly from the summit of the ovary, without the intervention of any other body; or it may be supported upon a small stalk, when it is said to be *stipitate*. The filaments or hairs of which it is composed may be simple, in which case the pappus is said to be *pilose*, *P. pilosus;* or they may have on their sides smaller filaments, resembling in some measure those of a feather, when the pappus is *plumose* or *feathery*, *P. plumosus*.

141. General Remarks.—In most cases the calyx is green, and resembles the leaves in texture. Frequently, however, it is of some other colour; and when the corolla is wanting, or the perianth single, it often assumes the most beautiful tints. In this case it is said to be *petaloid* or *corolliform*. Although generally shorter than the corolla, it sometimes equals or exceeds it in length. It may be *free*, or, on the other hand, in some degree *adherent* to the ovary.

Recapitulation.

135. What is meant by the Perianth? Is it ever wanting? Is it always, when present, double? When single, how can it be determined whether it is a calyx or corolla? Define the Calyx.—136. What are the leaves of the calyx named? When the sepals are united, what term is applied to the calyx? What is a polysepalous calyx? What is meant by persistent and caducous?—137. What terms are applied to the monosepalous calyx, with reference to the degree of union of its parts? What is a regular calyx, and the reverse?—138. What forms are assumed by the monosepalous calyx?—139. Of how many sepals may a calyx consist? What forms are assumed by the polypetalous calyx? How are the sepals described?—140. Describe the Pappus. How many varieties does it present?—141. Is the calyx always green? What proportion does it bear to the corolla?

CHAPTER XII.

THE COROLLA.

142. General Idea of the Corolla.—Within the calyx is the *Corolla*, a verticil of leaves, of more delicate texture, and generally more highly coloured. It immediately surrounds the stamens, and is that part popularly called the Flower. The leaves of which this verticil is composed are named *Petals*. Like the sepals, or leaves of the calyx, the petals are either free, or united by the edges in various degrees. When they are united, the corolla is said to be *monopetalous* or *gamopetalous*, Pl. XIII, Fig. 159; when free, it is *polypetalous*, Pl. XIII, Fig. 163. In many cases each petal exhibits two more or less distinct parts: the *Claw*, *Unguis*, or lower, contracted part by which it is attached to the receptacle; and the *Lamina*, or *Limb*, which is the expanded part, Pl. XII, Fig. 157. The unguis is thus analogous to the petiole, and the lamina to the blade of the leaf. The petals vary exceedingly in figure, being *roundish*, *ovate*, *lanceolate*, *obtuse*, *acute*, *entire*, *emarginate*, &c., the same terms being applied to them as to the leaves. When the petals, whether free or united, are equal to each other, the corolla is said to be *regular*, Pl. XII, Fig. 155, 156. When the reverse is the case, that is, when the petals are not equal, or when they adhere so as not to have a symmetrical form, it is *irregular*, Pl. XIII, Fig. 161, 163.

143. Monopetalous Corolla.—In a corolla of which the petals are united, three parts are distinguished:—1, a lower, narrow, more or less tubular and elongated part, named the *Tube*, *Tubus*; 2, a part continuous with the tube, more or less dilated, often spreading out flat, or

even recurved, and named the *Limb, Limbus ;* 3, the circular line at which the tube and limb unite, or the *Throat, Faux*. The tube is formed by the united claws, the limb by the laminæ of the petals. A monopetalous corolla may be regular or irregular.

144. REGULAR MONOPETALOUS COROLLA.—The semblance of various familiar objects is assumed by the monopetalous corolla in its modifications. Thus it may be,

1. *Bell-shaped* or *Campanulate*. *Corolla campanulata*. When it resembles a bell, the tube being inconspicuous, the limb bulging out and gradually widening, with the mouth spreading; as in *Campanula*. Pl. XIII, Fig. 159.

2. *Funnel-shaped*. *C. infundibuliformis*. When the tube is narrow, but gradually dilates, and the limb preserves nearly the same direction; as in *Nicotiana*. Pl. XIII, Fig. 160.

3. *Tubular*. *C. tubulata*. When narrow and elongated. Pl. XVII, Fig. 212.

4. *Salver-shaped*. *C. hypocrateriformis*. When the tube is long, narrow, and nearly of equal diameter throughout, while the limb spreads out flat; as in the Primrose. Pl. XII, Fig. 155.

5. *Rotate* or *Wheel-shaped*. *C. rotata*. When the limb is spreading, and the tube very short; as in *Borago*.

6. *Pitcher-shaped*. *C. urceolata*. When globular or egg-shaped, and contracted at the mouth; as in *Vaccinium*.

145. IRREGULAR MONOPETALOUS COROLLA. — The following are the principal varieties of this kind of corolla :—

1. *Ringent* or *Lipped*. *C. ringens, labiata*.—When the tube is narrow, the throat more or less dilated, and the limb divided into two unequal parts, one of which is

named the upper, the other the lower lip. This kind of Corolla is seen in Rosemary, Thyme, the Deadnettle, and other plants of the natural family of *Labiatæ*. Pl. X, Fig. 126. Pl. XIII, Fig. 161.

2. *Masked* or *Personate*. *C. personata*. When the tube is more or less elongated, the throat wide, but closed by the approximation of the opposite sides of the limb, which is divided into two lips; as in *Antirrhinum*. Pl. XIII, Fig. 162.

3. *Spurred*. *C. calcarata*. When the corolla has at its base a hollow prolongation like a horn; as in the figure last referred to.

4. *Strap-shaped*. *C. ligulata*. When tubular at the base, then slit on one side, so that the limb becomes flat; as in the Dandelion. Pl. XVI, Fig. 210, 211.

146. Terms applied to the Parts.—The various parts of the monopetalous corolla present numerous modifications, which require to be attended to. Thus:

The *Tube* may be *cylindrical*, as in the Lilac; *long*, as in the Primrose; *short*, as in the Bell-flower; *inflated* or bulging; *smooth*, *striated*, *angular*, &c.

The *Throat* may be *open*, as in Digitalis; *closed*, as in Snap-dragon; *crowned* with projecting teeth or appendages of various forms, as in Borage and Comfrey; *hairy*, as in Thyme; *naked*, or without hairs.

The Limb may be *erect*, as in Hound's-tongue; *spreading*, as in the Primrose; *reflexed*, or bent outwards, as in Solanum; *toothed* on the margin, or according to the number and depth of its divisions, *trifid*, *quadrifid*, *quinquefid*, *tripartite*, *quadripartite*, *quinquepartite*. The divisions of the limb are described in the same manner as leaves.

147. Polypetalous Corolla.—When a corolla is

composed of two petals, it is termed *dipetalous ;* when of three, *tripetalous ;* of four, *tetrapetalous,* Pl. XII, Fig. 156 ; of five, *pentapetalous,* Pl. XIV, Fig. 175 ; of six, *hexapetalous.* The petals may be *sessile,* or *unguiculate ;* and the length of the unguis may be *shorter* or *longer* than the calyx. They may be

1. *Erect. Petala erecta.* In the direction of the axis of the flower ; as in *Geum rivale.*

2. *Spreading. P. patentia.* When they are nearly at right angles to the axis of the flower ; as in *Rosa.*

3. *Reflected. P. reflexa.* When bent or curved outwards and downwards.

4. *Inflected. P. inflexa.* Curved toward the centre of the flower.

The petals vary exceedingly as to form in different plants, and are described in the same manner as the sepals and leaves, being *roundish, ovate, obovate, obcordate, elliptical, lanceolate, incised, lobed, smooth,* &c. Sometimes they present very singular forms. Thus, they are

Helmet-shaped or *Galeated. P. galeiformia.* When vaulted, hollow, and somewhat resembling a helmet ; as in Monk's-hood, *Aconitum Napellus.*

Cowl-shaped or *Cuculliform. P. cuculliformia.* Having the form of a cowl or hood ; as in Columbine and Larkspur.

Considered individually, a petal, as already stated, generally presents two distinct parts, the *Unguis* or *Claw,* and the *Lamina* or *Scale,* Pl. XII, Fig. 157. The claw is the narrow part at the base, by which the petal is attached to the receptacle, the lamina being the expanded part. The claw may be so short as to be scarcely distinguishable, or elongated so as to exceed the calyx.

As the monopetalous corolla may be regular or irregular, so also the polypetalous.

148. Regular Polypetalous Corolla.—Three principal modifications of this kind of Corolla are described.

1. The *Cruciform*. *C. cruciformis*. When four petals, having elongated claws, are placed in pairs, opposite to each other, in the manner of a cross; as in Wall-flower, Cabbage, and Water-cress, Pl. XII, Fig. 156.

2. *Caryophyllaceous*. *C. caryophyllacea*. When there are five petals, of which the claws are very long, and covered by the calyx, which is also very long and erect; as in the Pink and Catchfly, Pl. XI, Fig. 142.

3. *Rosaceous*. *C. rosacea*. Of five roundish spreading petals, of which the claws are very short; as in the Rose, Apple, Cherry, and Ranunculus, Pl. XIV, Fig. 175. The number of petals may vary, however, from three to six.

149. Irregular Polypetalous Corolla.—When the petals are unequal, the corolla is said to be irregular. This often happens in the Cruciform corolla above described, two of the petals being larger than the rest. Among the most remarkable corollas of this kind are the following:—

1. The *Papilionaceous*. *C. papilionacea*. Pl. XIII, Fig. 163. It is so named on account of its fancied resemblance to a butterfly, and is composed of five petals, distinguished by appropriate names. The large petal at the back, Fig. 164, is named the *standard*, *vexillum*; the two lateral petals, which are equal, Fig. 165, the *wings*, *alæ*; and the two inferior petals, Fig. 166, also equal, and often united by their lower margin, into a concave blade, named, from its appearance, the *keel*, *carina*. This kind of corolla is that seen in the great natural family of Leguminosæ, such as the Pea, the Bean, and Vetch. Sometimes, however, the petals of the papilionaceous corolla are united at the base, where they form a tube; as in Clover.

2. *Anomalous*. *C. anomala*. Of five irregular petals, and somewhat resembling the papilionaceous corolla; as in the Violet.

3. *Incomplete*. *C. incompleta*. When petals, which analogy would lead us to expect, are wanting; as in *Rittera*, Pl. XIII, Fig. 168, a rosaceous corolla, having only a single petal.

160. Position of the Petals.—Considered with reference to the sepals, the petals may be placed as follows:—

1. They may be *opposite* to the sepals, that is, the outer surface of the petal may be placed opposite to the inner surface of the sepal, so that the petals and sepals may correspond in position; as in the Barberry.

2. They may be *alternate*, that is, the petal may be placed, not opposite to the sepal, but opposite to the space between two sepals; as in the Wall-flower.

These circumstances refer not only to the polypetalous, but also to the monopetalous calyx and corolla.

The petals, whether united or free, may be placed upon the receptacle, immediately within or above the sepals, as in the Primrose and Ranunculus; or they may be attached to the margin of the tube of the calyx, at a distance from the receptacle, as in the Rose and Strawberry; or they may come off from the summit of the ovarium, as in the Thistle and Valerian.

151. Other circumstances of the Corolla.—The corolla, although generally longer than the calyx, may be shorter, and the relative proportions of the sepals and petals afford good distinctive characters. When the corolla falls off as soon as it expands, it is said to be *fugacious*, *C. fugax*; when it falls after the bursting of the anthers, it is *deciduous*, *C. decidua*; when it remains after fecundation, in a withered state, it is *marcescent*, *C. marcescens*. The colours exhibited by the corolla are of almost every possible variety of tint, excepting black,

and depend upon the coloured fluids or granules in the cells of its tissue. The odours emitted by it are also extremely varied, although less capable of being defined. The petals are composed of cellular tissue, in which are distributed vascular fasciculi, and are covered on both surfaces with a delicate epidermis.

RECAPITULATION.

142. What is placed immediately within the calyx? What name is given to the leaves of the corolla? When the petals are united, what is it said to be? What is a polypetalous corolla?—143. What parts are distinguished in the monopetalous corolla?—144. What are the principal varieties, as to shape, of the regular monopetalous corolla?—145. Define a labiate corolla. Mention the varieties of the irregular monopetalous corolla.—146. Does the tube vary in form, and other circumstances? What modifications does the limb present? —147. How is a corolla named with reference to the number of its petals? What are the principal directions of the petals? How are they described? What singular forms do they present? Into how many parts is a petal divided?—148. What are the principal kinds of the regular polypetalous corolla?—149. Describe the papilionaceous corolla. What is meant by anomalous and incomplete?—150. How are the petals placed with reference to the sepals?—151. What proportion does the corolla bear to the calyx? What terms referring to duration are applied to the corolla? Make a general statement as to its colours and odours. Of what are the petals composed?

CHAPTER XIII.

THE STAMENS.

152. Nature of the Stamens.—Within the corolla is a verticil of modified leaves, which differ so much in form from those organs, that their analogy could not at first sight be suspected. Their function too is different, for they are the organs by means of which the rudimentary ovula or seeds are impregnated. They are thus analogous to the male organs of animals, while the central part, or pistil, represents the female organ. The stamens and pistils then are the sexual or reproductive organs of plants. Generally they both exist in the same flower, which is thus said to be hermaphrodite or *perfect.* Sometimes, however, a flower has only stamens, when it is said to be *male* or *sterile;* or it has only pistils, when it is *female* or *fertile.* When a male flower and a female flower, or several flowers of each kind, are placed on the same individual plant, the latter is said to be *monœcious;* as the Hazel. When an individual plant bears flowers with stamens only, and another individual of the same species bears pistils only, the species is said to be *diœcious;* as the plant named Dog's Mercury. When on the same individual plant, or on different individuals of the same species, are placed male flowers, female flowers, and perfect flowers, the species is said to be *polygamous;* as the Pellitory. In Pl. XIV, Fig. 175, are seen the tips of the five sepals, the five petals, the five stamens, the pistil in the centre, and between the stamen scales fringed with glandule-tipped filaments.

153. Number and Proportion of Stamens.—The number of stamens varies in different plants from one to

a hundred or more. When a flower has only a single stamen, it is said to be *monandrous*; when it has two stamens, *diandrous*; when three, *triandrous*; when four, *tetrandrous*; five, *pentandrous*; six, *hexandrous*; seven, *heptandrous*; eight, *octandrous*; nine, *enneandrous*; ten, *decandrous*, &c. When a flower contains more than ten, but less than twenty, it is *dodecandrous*; and when a great number, *polyandrous*. Very frequently the stamens are *equal* in length; as in *Parnassia*, Pl. XIV, Fig. 175; but often *unequal*. When of four stamens, two are equal, and longer than the other two, the stamens are *didynamous*; as in the Dead-Nettle and Thyme. Six stamens, of which four are equal and longer than the rest, are *tetradynamous*; as in the Wall-flower and Turnip. In many other cases, some of the stamens are longer than the rest, as in *Geranium* and *Malva*, but no particular terms are applied to them.

154. Position and Direction of Stamens.—Generally the stamens, when equal in number to the petals, are *alternate* with them; but sometimes they are *opposite* to the petals. When the number of stamens is double that of the petals, half of them are alternate, the other half opposite to the divisions of the corolla. They may be opposite to the sepals, as in most cases; or alternate. With respect to their direction, stamens are named as follows:—

1. *Erect*. *Stamina erecta*. When parallel to the axis of the flower; as in Lilies.

2. *Inflected*. *St. inflexa*. When curved toward the centre of the flower; as in *Lamium*.

3. *Reflected*. *St. reflexa*. When bent outwards; as in *Parietaria*.

4. *Spreading*. *St. patentia*. When spread out at right angles to the axis of the flower; as in *Rosa*.

5. *Pendulous*. *St. pendentia*. When so slender as to be unable to support themselves; as in the Grasses.

6. *Ascending.* *St. adscendentia.* When directed toward the upper part of the flower; as in *Salvia.*

7. *Declinate.* *St. declinata.* When directed toward the lower part of the flower; as in *Æsculus.*

155. Parts of the Stamen.—The stamen is essentially composed of two parts; the *Anther, Anthera,* a membranous, generally two-celled sac; and the *Pollen,* a substance usually formed of numerous minute grains, containing the fecundating matter. Very frequently, however, a third part exists, namely the *Filament, Filamentum,* varying in length, and elevating the anther. The filament is thus merely an accessory part of the stamen, which is often *sessile,* being attached without the intervention of that part. Pl. XIV, Fig. 176, represents a stamen, *a* being the filament, and *b,* the double-celled anther.

156. The Filament.—Although very frequently elongated and thread-like, as its name implies, the Filament, *Filamentum,* presents various forms, it being:—

1. *Filiform.* *F. filiforme.* Like a thread, as is generally the case.

2. *Capillary.* *F. capillare.* Slender, like a hair; as in Grasses.

3. *Subulate* or *Awl-shaped.* *F. subulatum.* Roundish and tapering toward the tip; as in the Tulip.

4. *Clavate.* *F. claviforme.* Club-shaped, larger at the upper end.

5. *Cuneiform* or *Wedge-shaped.* *F. cuneiforme;* as in *Thalictrum.*

6. *Flattened.* *F. planum;* as in *Vinca.*

7. *Petaloid.* *F. petaloideum.* Broad, thin, and coloured; as in *Nymphæa alba.*

Various other forms are assumed by it. Usually the filaments are all free, or destitute of adhesion; but sometimes they are connected by their sides. Thus the Stamens may be:—

1. *Monadelphous. St. monadelpha.* When all the filaments are united in part of their extent so as to form a tube; as in Malva.

2. *Diadelphous. St. diadelpha.* When the stamens are united into two sets; as in *Fumaria* and *Genista.*

3. *Polyadelphous. St. polyadelpha.* When the stamens form three or more parcels; as in *Hypericum.*

157. The Anther.—The membranous sacs, constituting the *Anther, Anthera,* are generally two, and placed in contact with each other, but often more or less separated by the intervention of a body named the *Connective.* Although thus most commonly *bilocular,* the anther is sometimes *unilocular,* being composed of a single cell; and more rarely *quadrilocular.* Each sac or cell has generally on some part of its surface a longitudinal groove, at which it opens. The surface on which this groove is placed, is named its *face,* while the other side is the *back.* Generally each cell has a longitudinal septum opposite the slit. Frequently the cells of the anther have little appendages, in the form of bristles or crests. The connective varies in form and extent, being usually little apparent, but sometimes very large. In the Sage it is forked, one division bearing a single-celled anther, the other bearing a rudimentary or abortive cell. In this case it is said to be *distractile.*

158. Attachment and Direction of the Anther.—According to the mode of its attachment, the anther is named as follows:—

1. *Basifixed. A. basifixa.* When attached by its base to the top of the filament.

2. *Mediifixed. A. mediifixa.* When the tip of the filament is attached to the middle of the back of the anther.

A different mode of naming the anthers with reference to their attachment is this:

1. *Innate. A. innata.* Attached by their base. The same as *basifixed.*

2. *Adnate. A. adnata.* Attached by their back. The same as *mediifixed.*

3. *Versatile. A. versatilis.* Attached by a single point of the connective, so as to turn to either side with the greatest facility.

Viewed with respect to their direction, the Anthers are:—

1. *Introrse. A. introrsæ.* When facing the axis of the flower.

2. *Extrorse. A. extrorsæ.* When their face is directed outwards.

159. Form of the Anther.—Anthers present a great variety of forms. Thus, they may be *spheroidal, globosæ,* as in *Mercurialis; didymous, didymæ,* when of two spheroidal lobes, as in *Euphorbia; ovoidal, ovoidæ; oblong, oblongæ; linear, lineares,* very long and narrow; *arrow-shaped, sagittatæ; heart-shaped, cordiformes; kidney-shaped, reniformes.* They may be *acute, acuminate, bifid, bipartite; two-horned, bicornes,* as in *Vaccinium Myrtillus; appendiculate, appendiculatæ,* having at their summit appendages of various kinds.

160. Dehiscence of the Anthers.—Sometimes before the flower is expanded, and sometimes afterwards, the cells of the anther open, and allow the pollen or granules contained in them to escape. This opening, or dehiscence, most commonly takes place in the seam or line of separation of the two valves, in which case the cells are said to be *longitudinally dehiscent, Loculi longitudinaliter dehiscentes;* as in the Tulip. Sometimes it takes place by slits or pores, which may be placed at the summit, *L. apice dehiscentes,* as in *Heaths;* or at the

base, *L. basi dehiscentes*, as in *Pyrola*. Sometimes also it takes place by small valves; as in the Barberry.

161. COHESION OF ANTHERS.—Generally, even when the filaments are united or coherent, the anthers are free; but sometimes the anthers unite so as to form a kind of tube, surrounding the style. This is the case in the extensive family of plants, named, on this account, *Synantheree*, such as the Dandelion, Daisy, and Thistle.

162. THE POLLEN.—The substance contained in the cells of the anther, and which is subservient to the fecundation of the ovules or rudimentary seeds, generally consists of a multitude of grains, and is named the *Pollen*. These grains vary much in form in various plants, being in most cases spherical or elliptical, sometimes cylindrical, square, triangular, flattened, or polyhedral. The membrane which surrounds the granules is generally smooth, sometimes bristly, or marked with prominences. When smooth, it is dry, but when covered with asperities, which are secreting organs, it has a clammy fluid spread over it. Although commonly distinct from each other, the grains sometimes cohere in clusters, or coalesce in masses. They are coated with two membranes, of which the inner is more delicate. When immersed in water, they assume a spherical form, the outer coat bursts, and the inner projects at one or more points. The cavity of the grains is filled with granules of extreme minuteness, collectively named the *fovilla*, varying in form, and having a rotatory motion of great rapidity.

163. DEVELOPMENT AND DISPERSION OF POLLEN.—At first the pollen presents itself in the form of a cellular mass filling the cavity of the cell of the anther, but having no attachment to its walls. By degrees the grains separate, enlarge, and assume their permanent form. When the cells of the anther open, the grains of pollen are generally discharged at once; but sometimes, when the discharge takes place by pores or holes, the grains

are gradually emitted, and in greater quantity than would fill the cells, so that they must be successively secreted, or at least enlarged. Some of the grains of pollen falling on the stigma, which is generally covered with a clammy fluid, emit a process, which, gradually elongating, makes its way into the cellular tissue of the style. The ovules then enlarge and are gradually perfected.

164. Insertion of the Stamens.—Three varieties of position with reference to the ovary, are distinguishable, and considered of great importance in the arrangement of plants.

1. *Hypogynous Insertion.* When the stamens, whether their filaments be free, or adherent to a monopetalous corolla, are attached or inserted *beneath* the ovary, they are said to be *hypogynous;* as in the Poppy and Hyacinth.

2. *Perigynous Insertion.* When the stamens are inserted upon the inner surface of the calyx, at some distance from the axis of the flower, they are *perigynous;* as in the Rose and Strawberry.

3. *Epigynous Insertion.* When the stamens, whether their filaments be free, or attached to a monopetalous corolla, are inserted upon the summit of the ovary, they are *epigynous;* as in Hemlock and Campanula.

In reality, however, the stamens always originate from the space between the base of the petals and the base of the ovary; the apparent differences of insertion being produced by differences in the adhesion of the ovary and floral envelopes.

Sometimes the filaments are attached to the style, the male and female organs being thus in a manner united. In this case the flower is said to be *gynandrous.*

165. General Remarks.—The filament consists of a ndle of woody fibre and spiral vessels, enveloped in ular tissue, and is analogous to the petiole of the leaf.

Although generally white, it is sometimes red, blue, or yellow. The anther, which is very frequently yellow, but also of other colours, is considered to be analogous to the lamina or expanded part of the leaf. Indeed, the gradual change of the petals, which are evidently modified leaves, into the stamens, is obvious in *Nymphæa* and many other plants. In the stamen, however, there is a part, the fovilla, or mass of pollen, which has nothing analogous to it in the petals, sepals, or leaves. Judging from what takes place in *Nymphæa*, it would be better to consider the filament as representing the leaf, and the two cells of the anther to have no analogue.

Recapitulation.

152. What verticil is placed within that of the petals? What is the function of the stamens? To what are the stamens and pistils analogous? Do they often exist together on the same flower? What is meant by perfect, sterile, and fertile flowers? What are monœcious, diœcious, and polygamous flowers?—**153.** What terms are applied to the flowers with reference to the number of their stamens? How are stamens named with reference to their relative length?—**154.** How are the stamens placed relatively to the divisions of the corolla? What are their principal directions?—**155.** Of what parts is the stamen composed?—**156.** Mention some of the forms assumed by the filament. When the filaments are connected, so as to form one, two, or more parcels, how are they named?—**157.** Of how many sacs or cells is the anther formed? What is the connective? Does it vary in form?—**158.** How is the anther named with reference to its mode of attachment? When is an anther said to be introrse or extrorse?—**159.** Does the anther vary in form?—**160.** How does its dehiscence take place?—**161.** Do the anthers ever cohere?—**162.** Give a general account of the pollen.—**163.** How is it developed and dispersed?—**164.** What is meant by hypogynous, perigynous, and epigynous, insertion of the stamens?—**165.** Is the analogy between stamens and leaves very obvious?

CHAPTER XIV.

THE PISTIL.

166. Nature of the Pistil.—The central organ of the flower is composed essentially of a *Germen* or *Ovarium*, containing the young *Seeds* or *Ovules*, and of a *Stigma*, or fleshy tip, which may either be seated directly upon the ovarium, or elevated upon a stalk, named the *style*. These parts collectively constitute the *Pistil*, *Pistillum*, of which fig. 177, Pl. XIV, represents the pistil, *a*; the style, *b*; the stigma, *c*. The pistil may be simple or compound, it being in the former case formed of a single leaf named the *Carpel*, *Carpellum*, in the latter of several carpels. Each carpel is an organ analogous to a leaf, folded inwards upon its midrib, so that its two edges coming into contact cohere, forming the *placenta*, to which the ovules or young seeds are attached.

167. The Ovarium.—Considering the single pistil then as a leaf folded inwards upon itself in the direction of the axis of the plant, we find that the ovarium or germen is the lamina, the style an elongation of the midrib, and the stigma the humid secreting apex of the latter. This appears obvious from the examination of what takes place in the double cherry-flower, in which the pistil is altered so as to assume the appearance of one of the common leaves of the tree, having the two sides of its upper or inner surface brought together, its margins in contact, its midrib prolonged, and its tip somewhat enlarged and discoloured. For the most part, the carpel is sessile, but in some cases it is elevated upon a stalk, named the *thecaphore*, which is thus analogous to the petiole of the leaf. When the pistil is composed of several leaves or carpels,

it is said to be compound or multiple. In this case, the carpels are usually arranged so as to form a single verticil, but sometimes so as to present several verticils placed within each other.

168. FORM AND RELATIONS OF THE OVARY.—Although generally *ovoidal* or *roundish*, the ovarium assumes a variety of forms, being *trigonal*, *tetragonal*, *pentagonal*, *lobed*, *depressed*, or more or less elongated and compressed. It is generally *free*, or not adherent to the calyx; as in the Hyacinth and Tulip; but sometimes it is united with the tube of the calyx, so that its summit alone is free; as in the Apple and Hawthorn. In the former case it is said to be *superior*, with relation to the perianth; in the latter, *inferior*. Sometimes the ovary is adherent in part of its extent, and free in the upper part; as is seen in the genus *Saxifraga*. When several ovaries are disposed upon the inner walls of a tubular calyx, they are said to be *parietal*, as in *Rosa*. The compound ovary often presents the appearance of a single body, divided internally by partitions, Pl. XIV, Fig. 179.

169. DISSEPIMENTS OF THE OVARY.—As a single carpel is analogous to a leaf, it never has an internal dissepiment or partition properly so called, although it may present membranous laminæ of various kinds. But when several carpels unite to form a compound ovary, they, being leaves folded inwards upon themselves, constitute a body which, on being cut across, generally presents a number of dissepiments. These partitions are always longitudinal or vertical, and are uniformly equal in number to the carpels. As the placenta is the enlarged margin of the carpel, the dissepiment is always connected with it; hence, a partition in an ovary not connected with the placenta, is not a true dissepiment. The dissepiments may alternate with the placentæ, when the latter are formed by the cohesion of the two margins of the same carpel; or they may be opposite to the pla-

centæ, when the latter are formed by the cohesion of the margins of contiguous carpels. Sometimes, in a compound ovary, the united sides of the carpels do not project so far into the cavity as to meet the axis; as in the Poppy. In this case, the placentæ are said to be *parietal*. Sometimes also the dissepiments become obliterated, so as to leave the placentæ in the middle, forming what is called *a free central placenta;* as in *Lychnis*.

170. THE OVULES.—The young seeds, or *Ovula*, are small pulpy bodies, supported by the placenta, and, after impregnation, becoming converted into perfect seeds, capable of germinating. Being attached to the placentæ, or margins of the carpels, they are analogous in position to the buds sometimes found on the edges of leaves; but their structure is different. The little stalk that supports the ovule is a prolongation of the placenta, and is named the *funiculus* by some, the *podosperm* by others. In almost all cases the ovule is enclosed within the ovarium; but in the Coniferæ and Cycadeæ, where the carpels are not involute, the ovules are exposed, or *naked*. At first the ovule seems to be of a uniform pulpy nature, but gradually discloses two integuments or sacs open at the top, and a central part named the *nucleus*. The outer sac, or coat, is named *primine*, the inner *secondine*, and the nucleus frequently has a thin coat named the *tercine*. These three parts are all connected at some part of their surface, and at the apex of the first two is a passage called the foramen.

171. THE STYLE.—The *Style*, *Stylus*, is the prolongation of the summit of the ovary which supports the stigma. When it is wanting, the stigma is said to be *sessile;* as in the Poppy. When the ovary is composed of a single [illegible] the style is also single; and the number of styles [illegible]ccording to the number of carpels, though, when [illegible]els are numerous, the styles may be united. The

following are among the most remarkable circumstances that require to be mentioned here. The style is,

1. *Lateral.* *S. lateralis.* When it arises from the side of the ovary; as in *Rosa.*

2. *Basal.* *S. basilaris.* When it appears to spring from the base of the ovary; as in *Alchemilla.*

3. *Included.* *S. inclusus.* When not projecting beyond the mouth of the flower; as in the Pea and Dead-Nettle, Pl. XIII, Fig. 160, 161.

4. *Protruded.* *S. exsertus.* When elongated, so as to appear externally of the flower; as in *Campanula,* Pl. XIII, Fig. 159.

5. *Vertical.* *S. verticalis.* Standing upright, or in the axis of the flower; as in *Lilium.*

6. *Ascending.* *S. ascendens.* Curved upwards; as in *Salvia.*

7. *Declinate.* *S. declinatus.* When inclined toward the lower part of the flower; as in *Dictamnus.*

Viewed with respect to form, it may be,

1. *Filiform.* *S. filiformis.* Slender, and of nearly equal thickness in its whole length.

2. *Subulate.* *S. subulatum.* Tapering toward the end.

3. *Trigonal.* *S. trigonum.* Three-sided; as in *Lilium.*

4. *Claviform.* *S. claviformis.* Enlarged upwards; as in *Leucojum.*

5. *Petaloid.* *S. petaloideum.* Expanded, thin, and resembling the petals; as in *Iris.*

Considered with reference to its divisions, it may be *simple,* without any division; or *divided.* When the division does not extend far, it is *slit;* when more prolonged, *partite.* Thus, it may be *bifid* or *bipartite; trifid, tripartite,* &c.

After fecundation, the style generally falls off, when it is said to be *caducous;* or it may remain, when it is named *persistent.*

172. THE STIGMA.—The part which, in impregnation, receives the pollen, is named the *Stigma*. It is composed of cellular tissue, and has its surface generally destitute of epidermis, so that, from transfusion of its fluids, or from secretion, it is usually moist. As already mentioned, it may be *sessile*, or, on the contrary, furnished with a style. In many plants there is only one stigma, while in others there are two, three, five, or many, the number of stigmas being determined by that of the styles. The stigma is generally *terminal*, or placed at the end of the style; but sometimes *lateral*, or occupying its side, as in *Ranunculus*. Considered with reference to various circumstances, it is named as follows:—

1. *Capitate*. *S. capitatum* or *globosum*. Of a spherical or roundish form; as in the Primrose.

2. *Hemispherical*. *S. hemisphæricum*. Of the form of half a sphere; as in *Hyoscyamus aureus*.

3. *Discoid*. *S. discoideum*. Flat, broad, and like a shield; as in Poppies.

4. *Stellate*. *S. stellatum*. Flat, and cut into several lobes; as in *Pyrola*.

5. *Lobed*. *S. lobatum*. Formed of two or more rounded lobes; as in *Lilium*.

6. *Claviform*. *S. claviforme*. Oblong and enlarged at the end; as in *Jasione*.

7. *Subulate*. *S. subulatum*. Roundish and tapering.

8. *Filiform*. *S. filiforme*. Thread-like.

9. *Capillary*. *S. capillare*. Slender like a hair.

10. *Slit*. Bifid, trifid, quadrifid, &c.

11. *Erect*. *S. erectum*. Having the same direction as the axis of the flower.

12. *Oblique*. *S. obliquum*. Directed to one side.

With respect to substance or consistence, it may be fleshy, *S. carnosum*; glandular, *S. glandulosum*; membranous, *S. membranaceum*. Its surface may be *smooth*, *velvety*, *downy*, *hairy*, or *feathery*.

RECAPITULATION.

166. Of what parts is the germen or ovary composed? What is meant by Carpel? To what is the carpel analogous? —167. Describe the carpel in a general sense. In what flower is the seed-vessel converted into a leaf? Is the carpel often sessile? What is the Thecaphore? What is a compound pistil? How are the carpels arranged in it?—168. What forms does the Ovary assume? What is meant by a superior or inferior ovary? When are the ovules said to be parietal? —169. Has a simple carpel Dissepiments? Are the dissepiments ever transverse? Is the dissepiment connected with the placenta? What is a parietal placenta? Are the dissepiments ever obliterated?—170. What are the Ovules? How are they connected with the placenta? Are ovules always inclosed in the ovary? What is their structure?—171. Define the Style. Is it always present? May there be more styles than one? When longer than the flower, what is it termed? What directions may it have? Does it vary in form? Is it often divided? How is it named as to duration? —172. What is the Stigma? What forms may it assume? Does it vary as to direction and consistence?

CHAPTER XV.

THE RECEPTACLE, DISK, AND NECTARY.

There are certain parts connected with the flower, which having been only incidentally spoken of in the preceding pages, require to be here described.

173. THE RECEPTACLE.—It has been stated, at p. 85, § 131, that the summit of the peduncle generally expands in some degree, so as to form a kind of disk, from which the floral verticils proceed. This part then is what is usually termed the receptacle of the flower. But the

term receptacle is used by botanists in different senses. Thus it is by some considered as merely the part on which the carpels or fruits are placed, Pl. XVI, Fig. 208, 209, and obtains the names of *Torus* and *Thalamus*. When it rises in the form of a column and bears the stamens, it has been named *Gonophorum*. When elongated and bearing on its summit the petals and stamens, it has been called the *Anthophorum*. When it bears only the ovarium, it has been designated as the *Carpophorum* or *Gynophorum*. In this case it may be either a roundish stalk, when it is named the *Podogynium* or *Thecaphorum;* or it may be much enlarged and fleshy, with numerous ovaria, when it is named *Polyphorum*. When lengthened into a tapering body with the styles adhering, it bears the name of *Rostrum*. These terms are perhaps useful in describing particular families.

174. The Disk.—Between the base of the stamens and that of the ovary is frequently a fleshy or glandular body, of a yellowish or greenish colour, which being variously modified has received various names. Very often it assumes the form of a fleshy ring, surrounding the base of the ovary, when it is named the *Hypogynous Disk*. When formed of several knobs or glands, it has been called the *Epipodium*. Sometimes it presents the appearance of a cup, and is named accordingly a *Cyathiform Disk*. When enlarged and inserted as it were under the ovary, to which it forms a kind of receptacle, it is the *Gynobasis*. All these varieties are *hypogynous*, or situated beneath the ovary, or around its base; but when the ovary is inferior, that is, when the perianth adheres to its sides, the disk becomes *epigynous;* as in the plants named *Umbelliferæ*, in which it has been called the *Stylopodium*. Sometimes also it is *perigynous*, or adheres to the sides of the calyx; as in the Almond and Cherry.

175. Nectaries.—Linnæus gave the name of *Nectary* to every part of the flower that contains or secretes a sac-

charine fluid, or even to every supernumerary part of a flower. Thus, the tube of monopetalous flowers, such as *Lamium album*, and the base of the united petals of others, as *Trifolium pratense*, is a nectary. Sometimes it is a prolongation of the calyx, as in *Tropæolum*, Pl. XIII, Fig. 170, or of the corolla, as in *Viola*, and *Antirrhinum*, Fig. 162; or a part of the petals or of some analogous organs, as in *Aquilegia* and *Aconitum*, Fig. 171, 174. The curious fringed scales of *Parnassia*, Pl. XIV, Fig. 175, were also considered of this kind, as were the disks mentioned in the preceding paragraph. The scales on the claws of the petals of *Ranunculus*, and the pits on those of the Lilies and Fritillaries, are also nectaries; as are the coronal appendages of Narcissus, and the inner minute scales of Grasses. If the term be necessary, it seems expedient to restrict it to those parts which actually secrete honey, the use of which some conceive to be to attract insects, for the purpose of assisting in dispersing the pollen.

RECAPITULATION.

173. What is commonly meant by the Receptacle? When is it named the Torus or Thalamus? What is the Gonophore?—Anthophore?—Carpophore?—Thecaphore?—Polyphore?—174. Where is the Disk situated? When is it hypogynous, epigynous, and perigynous?—What is meant by the term Nectary? What parts of plants secrete honey?

CHAPTER XVI.

THE FRUIT.

176. General Idea of the Fruit.—The *Fruit*, *Fructus*, Pl. XIV, Fig. 179, 180, 181, 182, is the ovary or germen arrived at maturity. Frequently there are connected with it persistent bracteæ, calyces, or corollæ, enlarged, and either dry or pulpy, which may also be considered as forming part of it. It is composed essentially of two parts, the *pericarp* and the *seed*, the former enclosing the latter. By this character a small fruit may be distinguished from a seed, as well as by its often having on some part of its surface some trace of the style or stigma. Many fruits, as those of the natural families of the *Umbelliferæ*, *Labiatæ*, *Boragineæ*, and *Grasses*, were formerly considered as naked seeds, but are now known to consist of seeds surrounded with a pericarp; the only naked seeds known being confined to the families of *Coniferæ* and *Cycadeæ*.

177. The Pericarp.—The part of the fruit which immediately invests the seed or seeds, and originally formed the ovarium, is the *Pericarp*, *Pericarpium*. The *base* of the pericarp is the part by which it is attached to the peduncle, and its *apex* is indicated by the remains of the style or stigma. The pericarp varies extremely in size, thickness, and texture; being from a twelfth of an inch to two feet or more in diameter, delicately membranous, spongy, succulent, fibrous, cartilaginous, woody, or bony. It is always formed of three parts: the *Epicarp*, *Mesocarp*, and *Endocarp*.

1. The *Epicarp*, *Epicarpium*, is an external thin membrane, or skin, which determines the form of the peri-

carp. Thus, in the Cherry, Pl. XV, Fig. 183, and in the Pea, Pl. XIV, Fig. 182, it is the outermost delicate covering or cuticle. 2. The *Mesocarp*, *Mesocarpium*, also named the *Sarcocarp*, *Sarcocarpium*, especially when thick and fleshy, is the layer immediately under the pericarp. It forms the pulpy part of the Cherry, and is also green and succulent in the Pea until it has attained maturity, when it dries up. 3. The *Endocarp*, *Endocarpium*, is the innermost membrane, varying in texture, and bounding the cavity which contains the seed. In the Cherry it is the hard shell of the seed, and in the Pea a dense glistening membrane.

In the Apple, Pl. XV, Fig. 184, the epicarp is formed by the cuticle of the enlarged tube of the calyx, the mesocarp is the pulpy mass formed by its parenchyma, and the endocarps are the thin walls of the cavities containing the seeds. In dry and thin pericarps, the parts are not so easily distinguished; but a minute inspection will not fail to trace them.

178. Composition of the Pericarp.—A fruit may be composed of a single carpel or pericarp, or of several pericarps, either separate or united. When the carpels are distinct, the fruit is said to be *apocarpous;* when coherent, *syncarpous*. The structure of a simple pericarp is well illustrated by the common pea, Pl. XIV, Fig. 182, which is a modified leaf, folded inwards, with the seeds attached to the margins, which are united and thickened, to form the placenta. When several carpels cohere, each carpel generally forms a complete cell, and the fruit may thus be *bilocular*, *trilocular*, *quadrilocular*, *quinquelocular*, or *multilocular*, one-celled, two-celled, &c. Sometimes, however, when the ovarium is thus divided into several distinct cavities, it undergoes modifications in the progress of its development, and may ultimately present a single cavity, or one divided by partial partitions. The walls of the cells are named *Dissepiments*, and are formed

of the sides of two contiguous carpels. The fruit of the *Datura Stramonium*, Pl. XIV, Fig. 179, has thus four cells, or loculamenta, formed by four dissepiments. The Apple, Pl. XV, Fig. 184, has five cells, formed of five carpels enveloped in a pulpy mass, and enclosed within the calyx.

179. DEHISCENCE.—Some fruits, on attaining maturity, continue closed, but in others the pericarp divides in a definite manner, and is then said to be *dehiscent*. The separate parts, in this case, are usually named *Valves*, and the lines of division *Sutures* or *seams*. When the sutures correspond with the cohering edges of the carpels, the dehiscence is termed *septicidal*; when they take place in the middle of the carpels, or in the position of the midrib, they are said to be *loculicidal*. In some few cases the pericarp opens transversely, or in a circular line transverse to the lines formed by the margins of the carpels. Many pericarps open irregularly, and in others the seeds escape by pores or small valves at the upper extremity.

180. VARIETIES OF THE FRUIT.—Fruits being extremely diversified in form and texture, have exercised the ingenuity of botanists in their arrangement. The subject has even been dignified with the name of *Carpology*, as if it formed a distinct science of itself. With equal reason might the consideration of each separate organ be held as a science apart, and then we should have each chapter of a treatise on plants headed by such general titles as Rhizology, Phyllology, Sepalology, and Petalology. It will suffice, on the present occasion, to define the principal, that is, the more remarkable and more common kinds of fruits. We may divide them, with Professor Lindley, into Simple, Aggregated, Compound, and Collective.

181. SIMPLE FRUITS.—Of fruits simple in structure,

and of which only one series is produced by each flower, the following are the most common :—

1. The *Follicle, Folliculus.* A dry pericarp, having the appearance of a folded leaf, and opening by one suture only, so that it may be considered as composed of a single valve, along the margins of which the seeds are disposed ; as in *Vinca* and *Caltha.*

2. The *Legume, Legumen.* Pl. XIV, Fig. 182. A pericarp formed of a single carpel, or leaf folded upon itself, with the edges adherent, and forming a suture, while another suture is formed along the midrib, so that a separation takes place into two valves. The Legume differs from the Follicle only in this latter circumstance. Sometimes, however, it is indehiscent. When a Legume is contracted in the spaces between the seeds, or when transverse partitions are there formed, it is named a *Lomentum.* Examples of the Legume are seen in the Pea, the Bean, Laburnum, and other plants with papilionaceous flowers.

3. The *Nucula.* Pl. X, Fig. 126 ; Pl. XVI, Fig. 201. A hard pericarp, of a horny or bony texture, indehiscent, and containing a single seed, to which it is not closely attached ; as in *Lamium* and *Borago.* It is also named *Nut, Nux ;* but is not what is commonly called by that name.

4. The *Drupe, Drupa.* Pl. XV, Fig. 183. A fruit of which the pericarp is thin, the mesocarp very thick and pulpy, the endocarp hard. The seed is single, although in the early state there are two, one of them usually becoming abortive. Examples are seen in the Cherry, Peach, Plum, and Apricot.

181. Aggregated Fruits.—The ovaria are simple, as in the preceding section, but arranged in several series in each flower.

5. The *Eterio.* Pl. XV, Fig. 186. A fruit composed

of numerous distinct indehiscent ovaria, placed upon a dry receptacle, as in *Ranunculus;* or upon a fleshy receptacle, as in the Strawberry; or numerous small drupes, as in the Rasp and Bramble.

6. The *Cynarrhodum.* Numerous hard, indehiscent, dry ovaria, enclosed within the fleshy tube of a calyx; as in *Rosa.*

182. COMPOUND FRUITS.—A compound fruit is one composed of several united ovaria. A fruit of this kind, as indicated by having several styles or stigmas, may be simple from the abortion of some of its seeds, and then assumes the appearance of a simple fruit.

7. The *Caryopsis.* This kind of fruit, which is peculiar to the Grasses, is one-celled, one-seeded, indehiscent, dry, with the pericarp so united with the seed as not to be distinguishable from it. From having two or more stigmas, the ovarium may be supposed to be of a compound nature, although it never has more than one ovule.

8. The *Achenium.* Pl. XVI, Fig. 204. A one-seeded, one-celled, indehiscent fruit, with the pericarp not adherent to the seed. Having two or more stigmas, the ovarium may, like the last, be supposed to be compound, although there is never more than one ovule. All the plants forming the natural order of *Compositæ* have fruits of this kind. The *Diachenium,* fig. 206, composed of two achenia, is the fruit of the *Umbelliferæ.*

9. The *Carcerulus.* Many-celled; the cells dry, indehiscent, few-seeded, cohering round a common axis; as in *Malva.*

10. The *Samara.* Two-celled; the cells dry, indehiscent, few-seeded, elongated into membranous expansions; as in the Ash, Elm, and Plane-tree.

11. The *Siliqua.* Pl. XIV, Fig. 180. An elongated, two-valved, many-seeded pericarp, having the seeds at-
ᵓd to two lateral placentæ, and a dissepiment formed

by a membrane, which is a prolongation of the endocarp; as in the Cabbage and Mustard. The *Silicula* differs merely in being proportionally broader; Pl. XIV, Fig. 181.

12. The *Capsule, Capsula.* Pl. XIV, Fig. 178. A dry, dehiscent, many-seeded, one-celled or many-celled pericarp; as in *Primula* and *Stellaria.* The *Pyxidium* is similar, but opens transversely; as in *Anagallis.*

14. The *Acorn, Glans.* One-celled, with one or few seeds, indehiscent, hard and dry, with its base enveloped by an involucrum or cupule. The fruit of the Oak, Hazel, and Chestnut, are of this kind.

15. The *Gourd, Pepo.* One-celled, indehiscent, fleshy, with numerous seeds attached to parietal pulpy placentæ; as in the Melon and Cucumber.

16. *Berry, Bacca.* Pl. XII, Fig. 185. An indehiscent, many-seeded, pulpy fruit; as in the Gooseberry and Currant.

17. The *Apple, Pomum.* Pl. XII, Fig. 184. Several membranous or cartilaginous carpels, containing few seeds, and embedded in a fleshy mass, formed by an enlarged calyx; as in the Apple and Pear.

18. The *Hesperidium.* A fleshy fruit, with a thick envelope, and divided internally into several cells by membranous dissepiments; as in the Orange and Lemon.

183. Collective Fruits.—Those of which the floral envelopes or bracteas are enlarged and thickened.

19. The *Fig, Syconus.* A fleshy receptacle, flattened or hollow, with numerous dry pericarps; as in *Ficus.*

20. The *Cone, Strobilus.* Pl. XV, Fig. 188. An enlarged Catkin, of which the scales bear naked seeds; as in *Pinus.*

The Pericarp, above described, encloses the seed or seeds, which are the ovules in their mature state.

RECAPITULATION.

179. What is meant by the Dehiscence? What parts are named Valves? What is a Suture? How may Fruits be arranged?—180. What are the principal simple fruits? Define the Follicle. In what respect does the Legume differ from the follicle? What is a Nucula? Describe the Drupa. —181. Define the Eterio and Cynarrhodum.—182. What are the principal kinds of compound fruits? To what plants is the Caryopsis peculiar? Describe the Achenium. In what respects is a Siliqua different from a Legume, and from a Silicula? Give some examples of the Acorn, Gourd, and Berry. What is a Capsule? Define the Pomum and Hesperidium.—183. Give an account of the Syconus and Strobilus.

CHAPTER XVII.

THE SEED.

184. NATURE OF THE SEED.—The impregnated and matured ovule is the *Seed*, *Semen*, which may be defined a body enclosed within the pericarp, and containing an organized embryo, which, on being placed in favourable circumstances, is developed, and converted into an individual similar to that from which it derived its origin. The reproductive organs of flowerless plants, such as sea-weeds and mushrooms, differ in structure and in their mode of germination, and are not considered as true seeds, but are named *Sporules*. The seed is attached to the placenta by a small pedicel or *Umbilical Cord*, also named *Podosperm*. In some plants, this pedicel is unusually expanded, and rising round the seed, forms a partial ·ering to it, named the *Arillus;* as in the Nutmeg,

in which it constitutes the part called "Mace." The point of attachment of the cord or podosperm, is named the *Hilum*. The seed is composed of an external skin, the *Testa* or *Perisperm*, and a *Kernel*, or *Nucleus*.

185. THE PERISPERM.—Although the covering of the ovule is often distinctly double, the perisperm of the mature seed seldom presents two distinct layers. Its surface is smooth, rough, or granulated, and its form various, being globular, ovoidal, elliptical, elongated, compressed, according to the form of the kernel, to which it is closely applied, but from which it may be easily separated. The *Hilum*, or mark left by the umbilical cord, varies in appearance, being sometimes very small, at other times large, but generally easily distinguishable, it being of a different colour. This part always indicates the true base of the seed. Its centre, through which the nutrient vessels pass into the endosperm, is the *Omphalodium*. From the hilum proceeds a bundle of vessels, constituting the *Raphe*, and terminating at the summit of the seed, forming the *Chalaza*. The raphe, when present, indicates the face of the seed.

186. THE KERNEL.—The *Kernel*, or *Nucleus*, is the part of the seed contained within the perisperm, and consisting of the *Embryo* and *Endosperm*, or of the former only. The Endosperm, also named *Albumen*, when present, encloses the embryo, being interposed between it and the Testa. It varies from fleshy to bony, is destitute of vessels, sometimes exceeds the embryo in size, but is often much smaller, and, as already mentioned, is frequently wanting. The *Embryo* is the essential part of the seed, and constitutes the rudiment of the future plant. It is composed of three parts, the *radicle*, the *plumule*, and the *cotyledonary body*.

187. THE RADICLE.—The *Radicular Body* or *Radicle*, *Radicula*, Pl. I, Fig. 4, *f*, is a conical body forming one extremity of the embryo, and, when germination takes

place, giving rise to the root. The direction of this part determines the position of the embryo, as it always points toward a small hole, the *foramen*, in the testa or outer coat of the seed. As this aperture may be placed near the hilum, or at a distance from it, or even on the opposite side, the embryo will be *erect*, *inverse*, or *transverse*. Sometimes the radicle is external and exposed; sometimes covered and concealed by a body or sheath named the *Coleorhiza*, which it bursts in germinating; and less frequently incorporated with the endosperm. These circumstances have given rise to a division of plants into *Exorhizous*, *Endorhizous*, and *Synorhizous*, with which correspond the *Dicotyledonous*, *Monocotyledonous*, and *Polycotyledonous* plants, the latter being the Coniferæ and Cycadeæ.

188. THE PLUMULE.—The part of the embryo which is to be developed into the stem, leaves, and flowers, is named the Plumule, Pl. I, Fig. 4, 9; and by some authors is subdivided into the *Caulicle*, or base of the stem, the *Cotyledonary Body*, and the *Gemmule*, so named because it is the first bud, composed of the rudiments of all the parts that are to be developed in the open air. The caulicle is the part which unites the radicle with the cotyledons and plumule, and is not always very obvious. The plumule, on being enlarged and unfolded, becomes the stem, leaves, and, in short, all the parts of the perfect plant.

189. THE COTYLEDONS.—The *Cotyledonary Body* is sometimes simple and undivided, thus constituting a single cotyledon; sometimes formed of two cotyledons united at their base. Plants whose embryos have a single cotyledon are named *Monocotyledonous*, while those which have two cotyledons form the class of *Dicotyledonous* plants. Sometimes there are more than two cotyledons, as in the Pines and other Coniferæ, in which the number varies, in different species, from three to twelve. In Pl.

I, Fig. 2 represents the seed of *Pinus Cembra*, having about twelve cotyledons; and fig. 3, a young plant of the Norfolk Island Pine, which has four cotyledons. In plants destitute of endosperm or albumen, the cotyledons are generally thick, and in those furnished with that organ, thin. It is therefore probable that they supply nourishment to the young Plant. After germination, they become thinner, are raised to the surface, acquire a green colour, and become the first or seminal leaves. In this case, they are said to be the *epigeal.* But sometimes they remain under ground, and are named *hypogeal.* The cotyledons are frequently straight, but they may also be arcuate, spiral, undulated, and of various forms. They are usually placed face to face, but often separated to some distance. When folded with their back to the radicle, they are said to be *incumbent*, and when their edges are presented to that part they are *accumbent.* As the disposition of the parts is different in the Dicotyledonous and Monocotyledonous Embryos, it is necessary to examine these two varieties separately.

190. Dicotyledonous Embryo.—In the embryo, of which the Cotyledonary Body has two distinct lobes, the radicle is cylindrical or conical, exposed, protruded, and elongates at germination so as to become the true root of the plant. The two cotyledons are attached to the caulicle at the same height, opposite to each other, and are generally thick. The gemmule is contained between the cotyledons, by which it is more or less concealed. Sometimes, however, the two cotyledons are intimately united, as in the Horse-Chestnut; or they are increased in number, as in the Coniferæ; or are accidentally absent, as in Cuscuta. In germination, the radicle elongates and becomes the root, the cotyledons rise above the ground, and are converted into leaves, and the gemmule unfolds into the stem, foliage, and flowers.

191. Monocotyledonous Embryo.—In monocotyle-

donous plants the embryo is generally a cylindrical or oblong, undivided, homogeneous body, in which there is no obvious distinction of radicle, plumule, or cotyledons. In germination, the upper end swells and remains within the perisperm, while the lower elongates, and emits one or several radicles, shooting downwards, and a slender green body, protruding from its upper portion, and rising into the air. The upper part remaining within the testa is the single cotyledon; the radicle is at first enclosed in a kind of sheath, named the coleorhiza, which it bursts; and the gemmule, also contained in the interior of the cotyledon, is composed of leaflets enclosing each other, the outermost usually covering the rest.

It is not merely in the seed that a difference of structure is shewn by these plants; but also in the stem, leaves, and floral organs. This subject has been briefly spoken of in §§ 34, 35, 36. The Acotyledonous Plants differ so much from the rest, and from each other, that it has been judged expedient to keep them apart in treating of the general structure of vegetables; so that what has hitherto been said refers exclusively to Flowering Plants. In the next chapter, a short account of the structure of the Flowerless, Acotyledonous, or Cryptogamous Plants, will be given.

Recapitulation.

184. Give a general account of the Seed. What is a Sporule? How is the seed attached to the placenta? What is the Arillus? Of what parts is the seed composed?—185. Describe the Perisperm or Testa. What is the Hilum? How is the Raphe formed?—186. Of what is the Kernel composed? Is the Albumen always present?—What parts enter into the composition of the Embryo? What different positions may it assume?—187. What names are given to

plants with reference to the position of the radicle?—188. What is the Plumule? Into how many parts is it divided? —189. Give an account of the Cotyledonary Body. What is meant by Monocotyledonous and Dicotyledonous? Are there ever more than two Cotyledons? Do the cotyledons vary in form and direction? Why are they distinguished into epigeal and hypogeal? When are they said to be incumbent and accumbent?—190. Describe the Dicotyledonous Embryo.—191. Describe the Monocotyledonous Embryo? Do Monocotyledonous differ from Dicotyledonous plants in the structure of the stem and leaves?

CHAPTER XVIII.

STRUCTURE OF FLOWERLESS PLANTS.

192. General Observations.—The plants which are destitute of flowers, and are therefore named Agamous, differ greatly in their structure and form from those to which the preceding observations apply. They also differ much from each other, so that they could scarcely be described in general terms. They are considered as forming the lower series of the vegetable kingdom, being of more simple organization than the rest; and they are those by which a transition is made into the animal kingdom, some of them being apparently allied to certain animals of the lowest order of organization. They are divided into the families of Ferns, Equisetaceæ, Lycopodiaceæ, Marsileaceæ, Mosses, Hepaticæ, Lichens, Characeæ, Algæ, and Fungi.

193. Ferns.—*Ferns*, or *Filices*, are the largest of those plants which are destitute of floral organs. They consist of a number of leaves, named *Fronds*, attached to a stem, which is either a subterranean rhizoma, or rises, like the trunk of a tree, to the height sometimes of fifteen

or twenty feet. Their stem is formed by the cohesion of the bases of the petioles round a cellular axis. Their fronds are sometimes simple, but more frequently divided, or variously decompounded, and in vernation are rolled up. The reproductive organs consist of *Thecæ*, or minute capsules, aggregated into little masses named *Sori*, of various forms, and variously arranged on the back of the frond, or along its margins. The thecæ are either pedicillate, and surrounded by an elastic ring, Pl. XI, Fig. 145, or sessile, and destitute of a ring. When the sori originate beneath the cuticle, they force it up in the form of a delicate covering, *Indusium* or *Involucrum*, Pl. XI, Fig. 144. The *Sporules*, or reproductive germs, are extremely small, and disposed without order within the thecæ. These plants approach in form, as well as structure, to the flowering plants, especially the *Cycadeæ* and *Coniferæ*.

194. Equisetaceæ.—Herbaceous perennial plants, with simple or branched; generally hollow, longitudinally striated stems, jointed at intervals, and having sheaths at the joints. The organs of reproduction are arranged in a terminal spike or catkin, composed of peltate scales, on the lower surface of which are *Capsules* or thecæ, filled with *Granules* of two kinds, some very minute, others larger, and enfolded by four elastic filaments. These larger granules are the reproductive *Sporules*.

195. Marsileaceæ.—Small aquatic plants, of which the reproductive organs are a kind of leathery *Involucres*, with one or more cells, containing *Sporules*, and placed at the base of the leaves.

196. Lycopodiaceæ.—These are intermediate in appearance between Mosses and Ferns. They are either stemless, with erect subulate leaves, or they have creeping stems and imbricated leaves. The organs of reproduction are sometimes small, globular, or reniform single-celled *Capsules*, containing numerous sporules, sometimes

larger capsules opening by two or three valves, and containing only a few large granules. The capsules are sometimes axillar and solitary, sometimes aggregated in the axils of bracteas, forming simple or digitate spikes.

197. MOSSES.—The *Mosses* are small plants entirely composed of cellular tissue, but having a distinct axis of vegetation, or stem, covered with leaves. Their reproductive organs are of two kinds: axillar, cylindrical, or fusiform bodies, containing minute roundish particles; and *Thecæ* or capsules, supported upon a stalk or *Seta*, covered with a *Calyptra*, closed by an *Operculum*, within which is a *Peristome*, composed of slender processes, named *Teeth*, and having a central axis or *Columella*, the space between which and the walls of the theca is filled with minute *Sporules*. In Pl. XII, Fig. 150 represents a portion of moss with its theca and operculum; Fig. 151, the calyptra. Pl. XVI, Fig. 213, shews the seta, theca, peristome, and operculum, of a moss; Fig. 214, the teeth of the peristome. The other bodies spoken of above are represented by Pl. XV, Fig. 190, 191, 192. The reproductive sporule, Fig. 193, is seen in the process of germination in Fig. 194; and Pl. XVI, Fig. 195, shews the same farther advanced; while Fig. 196 shews another moss in the same state.

198. HEPATICÆ.—The *Liverworts* or *Hepaticæ*, are small plants, having a loosely cellular substance, and presenting the appearance of simple or lobed membranes, furnished with a midrib, or having a small branched stem bearing leaves. The reproductive organs are either oblong or globular bodies, containing a minutely granular substance, escaping by an aperture, or *Capsules* containing numerous sporules mixed with spiral filaments, covered at first with a *Calyptra*, at length rising on a peduncle, and opening into two or four valves. Pl. XII, Fig. 152, represents one of these globular capsules, with its calyptra.

199. Lichenes.—The *Lichens* vary in form and texture, but may be defined as composed of fronds or *Thalli*, presenting the appearance of membranous, powdery, leathery, or gelatinous crusts or expansions; simple or variously lobed; spreading on the ground, on rocks, stones, the bark of trees, and dead wood. The reproductive organs are of two kinds: *Soridia*, or heaps of pulverulent bodies scattered over the surface of the thallus, Pl. XVI, Fig. 197; or *Apothecia*, varying in form and colour, Fig. 198, and enclosing the sporules.

200. Characeæ.—These are aquatic plants, having slender, branched, green stems, with verticillate leaves, on the upper of which are *Capsules*, each surrounded by two or three bracteas, and containing numerous sporules. There are also on the branches sessile and rounded tubercles of a reddish colour.

201. Algæ.—These plants are aquatic, some growing in the sea, others in fresh water. They are destitute of leaves properly so called, and present various forms, being globular, filamentary, tubular, or laminar, simple or branched, continuous or articulated. Their organs of reproduction are minute *Sporules*, contained in *Sporidia*, variously grouped, and usually placed in the substance of the plants. All the plants named Sea-weeds belong to this family.

202. Fungi.—The *Fungi* are extremely diversified in form, consistence, and colour; being globular, oval, cup-shaped, elongated, filamentary, simple or branched, and composed of congeries of cellules. Their reproductive organs consist of *Sporules* lying loose in the cellular tissue, or enclosed in membranous cases or sporidia. Many of them have a form resembling that of an umbrella, being furnished with a *Pileus* or convex part, having on its lower part *Tubes* or *Laminæ*, and a central or lateral *Stipe*. Fig. 154, Pl. XII, represents a mushroom covered with its *Volva*. Fig. 153, shews the stipe and pileus of

another, with the former having upon it an *Annulus*, being the remains of the volva. These plants, together with the Algæ, are considered as forming the lowest or least organized of the vegetable series.

203. STRUCTURE OF ACOTYLEDONES.—It was stated, § 34, that, on account of their peculiar mode of growth, the stems of Dicotyledonous trees are named Exogenous ; those of Monocotyledonous trees, Endogenous. Another term, *Acrogenous*, has been applied to the stems of Ferns, which are cylindrical, usually hollow, or, if solid, having the central part composed of a spongy substance, destitute of woody fasciculi or medullary rays, and having their external part composed of very hard plates folded upon themselves. These plates, on being once formed, continue without change as to number or quantity, and seem to be prolongations of the woody matter lying within the stalks of the leaves. Stems of this kind differ in structure from those of exogenous plants, which increase by addition to the outside of their wood, and from those of endogenous plants, which increase by addition of woody or vascular fibres to their interior. They seem to undergo little or no enlargement in diameter, and merely to elongate by the extension of their tip, whence the term Acrogenous, by which they are distinguished.

Another mode of growth, termed *Centrifugal*, is that of fungi, lichens, and other acotyledonous plants, which consist either of a spongy mass, or of filaments radiating from a common centre. " In an obscure plant called Marchantia, Mirbel found, that a little thin green plate was first formed by the action of the reproductive granules ; and that it was from the edges of this plate, when once fully formed, that all the succeeding expansions took place, as from a common centre, but always upon the same plane ; so that in such plants the central part is the oldest, and the circumference the youngest. This is very apparent in lichens, which, when very large, are always

dead in the centre, while they continue to go on growing from every part of their margin. Fairy rings are an exemplification of the same thing in fungi. These appearances are external indications of the centrifugal growth of the subterranean stems of certain Agarics, which originally spring from a common point, continually spreading outwards upon the same plane, the central or first-formed parts perishing as the circumferential or latest-formed parts develope."

Recapitulation.

192. What are the families of Flowerless Plants?—193. Give a general account of Ferns.—194. Describe the Equisetaceæ.—195. What are the Marsileaceæ?—196. What plants do the Lycopodiaceæ resemble? Describe their organs of fructification.—197. What parts are observed in the theca or capsule of a Moss?—198. Describe the reproductive organs of the Hepaticæ.—199. Where do Lichens grow? What are their Soridia and Apothecia?—200. Describe briefly the Characeæ.—201. Of what nature are the reproductive organs of the Algæ.—202. What parts are observed in the Mushrooms properly so called?—203. Why are the stems of Ferns said to be Acrogenous? Give an account of their structure. In what plants is the Centrifugal mode of growth observed?

SECTION II.

FUNCTIONS OF PLANTS.

CHAPTER XIX.

GERMINATION, GROWTH, AND MATURATION OF PLANTS.

204. Germination.—Plants being destitute of sensibility and voluntary motion, have a less complex structure than animals, to which these faculties are essential. Fixed in a particular spot, they increase in size by imbibing the nutritious elements by which they are surrounded, are acted upon by the atmospherical agents, and having reached the term of their annual or final development, produce embryos of future individuals of their species. Their functions are thus confined to nutrition and reproduction, the most intelligible mode of observing which is to trace a plant from the commencement of its growth to the completion of its organization. Every plant originates from an impregnated ovule which has been converted into a ripe and perfect seed. The act by which a seed, on being placed in suitable circumstances, becomes developed so as to produce a plant similar to that from which it sprung, is named *Germination*.

205. Conditions of Germination.—The agents essential to this process are heat, moisture, and air. If a seed be put in a place, the temperature of which is below the freezing point, it remains torpid. On the other hand,

if the heat be very high, the seed is quickly dried up, or, if kept moist, is softened and deprived of its vitality. But if the temperature be moderate, and other circumstances favourable, it soon begins to germinate. Moisture is equally necessary, but must also be supplied in moderate quantity. It softens the covering of the seed, which is often very hard, rendering it more easy for the embryo to burst it; and it affords a vehicle to the substances which nourish the young plant. Atmospheric air is not less necessary; for seeds buried to such a depth as to be beyond its influence, remain in torpidity. But light, instead of accelerating the development of the embryo, seems to retard it, and seeds are found to germinate readily in darkness. The conditions required for germination then, are access to moisture and air, and a moderate temperature. These conditions are frequently found to exist in the ordinary circumstances in which seeds are left after dropping from the plants which produced them, but are more surely obtained by the interference of man, whose ingenuity enables him to place them in the most favourable circumstances.

206. Progress of Germination.—When a seed is placed in circumstances favourable to germination, it absorbs moisture, swells, and bursts its testa, which splits irregularly in most species, but in some in a definite manner. The embryo is seen to enlarge, and to elongate in two opposite directions; one of its extremities tending upwards into the region of air and light, while the other passes downwards into the earth. The period that elapses between the time when seeds are placed in a situation favourable to their development, and the time of germination, varies from a few days to two years. Thus, the Common Cress germinates in two days, the Turnip in three, the Lettuce in four, Grasses in a week, Hyssop in a month, many pines in a year, and the Hazel and Holly not until two years. When the impulse has been given

to the vital principle, the parts gradually enlarge, the first leaves are unfolded, and the cotyledons rise to the surface and assume a green colour.

207. Chemical Action.—In the seed has been deposited a great quantity of fecula and carbon, and its parts have been indurated. The moisture penetrates the testa, and collects especially in the cellular tissue near the tip of the radicle. It is then imbibed by that organ, and passes into the cotyledons, as well as the albumen. One of its uses is to dissolve the substances prepared for the nourishment of the embryo, and to convey them to it. The oxygen of the atmosphere and water unites with the carbon of the endosperm, producing carbonic acid, which is expelled; and the remaining substances are converted into saccharine matter, which supplies nutrition to the embryo. Presently the cotyledons and first leaves supply additional nourishment by aerating the fluids which they contain, and which are derived from the soil and the atmosphere. The germination of dicotyledonous plants is somewhat different from that of the monocotyledonous.

208. Germination in Dicotyledones.—In the dicotyledonous seed, the radicle is generally conical and protruded, the caulicle cylindrical, and the gemmule placed between the bases of the two cotyledons, which are applied to each other. The entire mass of the seed becomes permeated by moisture and swells. The perisperm or testa bursts; the radicle elongates, and gives out delicate ramifications; the gemmule rises and emerges from between the cotyledons; the caulicle elongates and raises the cotyledons, which separate, expand, become green, and are converted into leaves. When albumen is present in the seed, it softens, and gradually disappears, being absorbed by the embryo.

209. Germination in Monocotyledones.—The embryos of monocotyledonous plants have a greater unifor-

mity of structure, so that their parts are often not easily distinguished until germination has commenced. The radicular extrêmity elongates, bursts through its sheath or coleorhiza, and passes downwards. Several radicles generally come off from the lower part of the caulicle, and when these are well developed, the principal radicle disappears, so that plants of this kind never have a tapering root, like that of the dicotyledones. The cotyledon enlarges, and is perforated by the gemmule, which emerges from its side or base, enclosed in a sheath, the coleoptile. It then perforates this sheath, and elongates.

210. Progress of Dicotyledones.—In this state the young plant consists chiefly of cellular tissue, but with vascular fibres forming a kind of cylinder in the centre. This cylinder is the medullary sheath, within it is the pith, and externally the bark. The root imbibes liquid, which passing upwards through the cellular tissue, enters the cotyledons, where it is aerated, and in part passes down through the bark into the root. The plumule gradually ascends, its rudimentary leaves are developed, and soon acquire their full size, when they aerate the sap or mass of imbibed fluid, give out oxygen, and retain carbon. The axis of the plant elongates, other leaves are developed upon it, and a layer of fibres is formed between the pith and the bark. At length, as the season draws to an end, the development of the plant is arrested, and the leaves fall off, while in the axilla of each is formed a bud, composed of a rudimentary branch and leaves. If now examined, the stem will be found composed of a central axis of dry cellular tissue forming the pith, a cylinder of woody tissue, and an outer cylinder of bark.

211. Continued Progress of Dicotyledones.—During the winter the plant remains in a torpid state, but on the return of warm weather vegetation recommences. The sap ascends through the wood of the previous year, the buds gradually expand into branches covered with

leaves, by which the fluids are aerated. Each new branch exhibits the same phenomena as the stem of the first year, on which a glutinous fluid, the cambium, is found interposed between the wood and the bark, in the place of which are ultimately formed a new layer of wood, and another of bark. The leaves fall as before, leaving buds in their axillæ. After a period of repose, vegetation is resumed in spring, continued through the summer, and produces the same results. Each successive year, a new layer of wood and a thinner layer of bark are added. When the tree has attained the age of puberty, which varies in different species, and in different individuals of the same species, flower-buds are formed, which unfold their parts. The anthers burst, and part of their pollen adheres to the humid stigma. The grains of pollen emit a delicate tube, which, penetrating the stigma and style, transmit the fecundating influence to the ovarium. The ovula being impregnated, the petals and stamens fade, the ovarium enlarges, and the seeds are perfected. At the end of the season, they fall to the ground, either contained in the pericarp, or after escaping from it, according to the species.

212. Progress of Monocotyledones.—It has been seen that the enlargement of the stems of dicotyledonous plants takes place by the addition of new matter between the wood and the bark, or near the circumference; whence these plants are named Endogenous, that is, growing at their exterior. But in monocotyledonous plants, the growth is in the inside; whence they are named Endogenous. When a monocotyledonous seed has germinated, and the plumule has shot up, a leaf is emitted from its base. This leaf is succeeded by another, arising from its axilla, and facing it; a third, a fourth, and others follow in succession, until the stem is ready to be produced. The bases of the leaves being upon the same plane, each having been produced from the axilla of the other, without any

intervening space, a kind of fleshy stock is produced by their union, consisting of parenchymatous tissue, with perpendicular fasciculi of vascular and woody tissue, continuous with the veins of the leaves. The whole body is thus a mass of cellular, vascular, and woody tissue, intermingled, without any distinction, into pith, medullary sheath, or bark. This mass now elongates upwards; leaves are developed from its central part or apex; the former leaves are left forming a circle at the base; and when the stem has ascended to some height, a new circle, or a spiral series, is formed. The new leaves thrust toward the circumference those which preceded them; the old leaves decay, their bases remaining as part of the stem; which does not increase in diameter, and has its central parts of softer texture than those toward the exterior, the pressure acting from within, so that the outer parts ultimately assume the appearance of a solid mass of woody fibres, the cellular tissue having become almost obliterated. In this manner, the growth of palms, and many arborescent monocotyledonous plants, takes place. Other plants of that series exhibit differences in their mode of development; the Grasses, for example; but in all, the stem differs from that of dicotyledonous plants.

213. Growth of Flowerless Plants.—The sporules of these plants appear to germinate from any part, there being in them no distinction into radicle and plumule. In some, however, roots and a stem are formed much in the same manner as in monocotyledonous plants. In Tree Ferns the stem appears to be produced by the bases of the leaves, § 203. In the purely cellular tribes, the parts seem to be mere expansions of the cellular tissue; but on this subject nothing very precise can be stated.

214. Growth of Plants in general.—By the absorption of fluid by the roots, a mass of nutritious matter is gradually accumulated in the stem and branches. This fluid passing into the leaves, is there subjected to a pro-

cess by which part of the water is discharged, the remaining part subjected to the action of the atmosphere; carbonic acid is generated, and then decomposed by the action of light; carbon is fixed in the form of a nutritive material, which is carried into the system; a further elaboration of this material takes place, after which it is applied to the development of all the organs; while, by certain changes, it is also converted into various matters, which are either retained, or ejected. The stems and branches, with the leaves and stipules, are gradually developed; the flowers make their appearance, and unfold their parts; the anthers shed their pollen, the application of which to the stigma is followed by the development of the ovules; the fruit is at length matured, and drops to the ground, where the seeds, under favourable circumstances, become developed into new individuals. The various processes by which the results of vegetation are obtained, may all be resolved into the two functions of Nutrition and Reproduction. But before treating of these, it is necessary to advert to circumstances having reference to the vital power of plants, the properties of vegetable tissues, and the agents by which vegetation is stimulated.

RECAPITULATION.

204. What are the principal functions of plants? From what do plants originate? What is meant by Germination? —205. What agents are essential to germination? Do seeds germinate at a temperature below that of freezing? What follows when the temperature is too high? What are the uses of moisture in germination? Is light beneficial? Is air necessary?—206. What happens when a seed is placed in circumstances favourable to germination? Do the seeds of different plants differ in their periods of germinating?—207. What changes are produced in the seed during germination?

—208. Describe the germination of Dicotyledonous Plants.—209. How does germination take place in Monocotyledonous Plants?—210, 211. Give an account of the progress of growth in Dicotyledones—212. Describe the progress in Monocotyledones.—213. How are Flowerless Plants developed?—214. Give a short account of the Growth of Plants in general.

CHAPTER XX.

VEGETABLE LIFE, PROPERTIES OF ORGANS, AND STIMULANTS TO VEGETATION.

215. Vegetable Life.—Plants exhibit phenomena similar to those which in animals are considered as characteristic of vital agency, agreeing with them in many essential respects, as has already been stated, § 10, although they differ in others, § 7, especially in being destitute of sensibility and voluntary motion. What life really is, whether it be a principle, or influence, or substance, apart from the material fabric by which its phenomena are exhibited, or merely the result of the operation of the elements of nature upon organs adapted for the purpose, seems to be as little known to the philosopher as to the clown. We may therefore speak of life, either as a distinct principle, or as the general result of the operations of an organized body. In reference to this subject, little more can be said of plants than that they are organized and living bodies, having a less complex structure, and exhibiting less remarkable vital actions than animals, between which and mineral bodies they are intermediate, although more intimately allied to the former than to the latter.

216. Properties of Vegetable Tissue.—The cellular and vascular tissues of plants possess various proper-

ties in common with animal tissues. Thus, they are extensile, elastic, and absorbent. But they are destitute of the irritability manifested by muscular fibre, and of the sensibility dependent upon nervous influence. The processes of secretion and circulation are performed in a different manner in plants and animals. From the manner in which the elementary organs are intermixed in plants, and the impossibility of tracing their actions separately, or in succession, our knowledge of their functions is very imperfect. The Cellular Tissue has the property of transmitting fluids in all directions. In many plants there is no other kind of tissue, and yet the sap circulates in all their parts. The pith, the medullary rays, the parenchyma of the leaves, and the greater part of the bark, are composed of it; and in all these parts, at some period, the fluids are diffused and propelled. The Woody Tissue is also pervious to fluids, and gives firmness and elasticity to the parts in which it occurs. The Vascular Tissue is partly subservient to the transmission of liquids, and partly of air; at least, the spiral vessels are generally believed to contain the latter. The elasticity of tissue is obviously displayed in many instances, and is more conspicuous when the parts are distended with fluid. The effect of moisture, producing what is called Hygroscopicity, gives rise to motions, which might often be supposed to depend upon irritability.

217. Irritability.—The irritability of plants, if not different from that of animals, is, at least, of a much inferior character; and has therefore been by some referred to a property, to which is given the name of Excitability. This property is defined as being that by which the tissue becomes in some manner or degree sensible of the action of external influences, and by which it resists such as would otherwise decompose it. It is a property of life, it is said, to resist destruction, and this property is possessed by plants in common with animals. The

irritability of animal organs, being inherent in muscular fibre, can have no place in plants; and what is meant by the term in Vegetable Physiology is merely the result of movements, which may be referred to other causes. The closing of the leaves and flowers of plants, the shrinking of others when touched, the motions of the leaves of *Dionæa*, and of the stamens of the Barberry, alluded to in § 9, are of this kind.

218. Sleep of Plants.—Toward the approach of night, in plants which have compound leaves, the leaflets fold together, and the petiole is bent downwards. At the return of day the petiole rises, and the leaflets expand. In some plants the leaves converge over the flowers; in many the flowers themselves close, in the absence of the direct light of the sun. The corollas of the Dandelion, Daisy, and many other *Compositæ*, become erect in gloomy weather, and spread out in sunshine. Phenomena of this nature have been termed the Sleep of plants, and are, no doubt, in some way owing to the action of light, although other causes may also operate.

219. Movements caused by Touch.—The Sensitive Plant, *Mimosa pudica*, has long been known for the property possessed by it, in common with other species, of folding up its leaves when touched, or burnt, or otherwise injured. The leaves of this plant are compound, with four pinnate divisions, each partial petiole being furnished with numerous pairs of leaflets. If one of the leaflets be touched, it rises along with its fellow, the leaflets successively bring their upper surfaces together in pairs, and incline toward the summit of the partial petiole; the other *pinnæ* go through the same action, the four partial petioles come together, and lastly, the petiole itself bends downwards. It appears that the elevation and depression of the leaf is somehow produced by the tissue in the tumid basal part of the petiole, for, if its upper portion be cut off, the petiole remains erect, but if its lower por-

tion, it remains depressed. This motion is analogous to that above mentioned, as referred to the sleep of plants; but its causes and mechanism are not well known.

220. Spontaneous Movements.—Some plants exhibit motions which have been called Spontaneous, merely because not excited by touch or external violence. Of this kind are those of the two lateral leaflets of the ternate leaves of *Hedysarum gyrans*, which are in continual motion, day and night, especially in warm weather. When the fruit of *Momordica Elaterium* has attained maturity, its peduncle is suddenly expelled, along with the seeds, and the mucilaginous fluid by which they are surrounded. But, according to Dutrochet, this phenomenon is caused by a circumstance of general occurrence in plants, to which he has given the name of Endosmose.

221. Endosmose.—Although vegetable and animal membranes, when examined with the microscope, are not observed to have any pores, but appear perfectly continuous, it is found that liquids readily pass through them. If mucilage, or gum dissolved in water, be enclosed in a piece of bladder, which is then immersed in water, a portion of the gum will pass through the bladder into the water, of which a portion will, on the other hand, pass into the bladder. If the experiment be reversed, so will the result. It is the same with milk, or any other liquid. The general law, according to M. Dutrochet, is, that when two fluids of unequal density are separated by a membrane, the denser fluid will attract the less dense. When the attraction is from without inwards, he names the action *Endosmose;* when from within outwards, *Exosmose.* The transmission he considers as caused by galvanic agency. There can be no doubt that many of the phenomena of vegetation are dependent upon this property of membrane; and some are of opinion, that it is the principal cause of the motion of the fluids of plants.

222. Action of Poisons.—As a proof of the existence

of sensibility, and of some kind of nervous system, in plants, has been adduced the action of many substances, which prove destructive to life, without corroding or decomposing the tissue. M. Marcet of Geneva found, that not only oxide of arsenic, corrosive sublimate, preparations of lead, tin and copper, potash, and other acrid poisons, on being absorbed by the roots, produce death; but also solutions of opium, nux vomica, belladonna, prussic acid, and other narcotic poisons, which are understood to act upon the nervous system in animals. From the experiments made he infers, that metallic poisons act on plants nearly as on animals, altering and destroying the tissue by their corrosive powers; and that vegetable poisons, especially those which cause death in animals by their action upon the nervous system, destroy life in plants without altering the tissue. Similar results have been obtained by M. Macaire and others. Yet nothing analogous to a nervous system, even of the kind observed in the lower series of animals, has been observed in plants.

223. Stimulants to Vegetation.—Whatever may be the kind or degree of sensibility possessed by plants, or whatever the peculiarities of the intimate structure of their organs, we know that their vital power languishes or remains dormant, or, on the other hand, manifests itself with greater energy, according to the varied influence of external agents. Thus, a seed will not germinate unless supplied with moisture and atmospheric air, and submitted to a moderate temperature; after a long drought, plants become shrivelled and languid; and, when deluged with continued rains, shoot out long but feeble stems, or, if they perfect the branches and leaves, bear little fruit. The stimulants to vegetation are light, heat, electricity, air, and water.

224. Action of Light.—When a plant is made to vegetate in a cellar or other dark place, it remains white;

and when brought into the light, soon acquires its natural green colour. The practice of blanching Celery, by covering it up from the light, is familiar to every one. Light being essential to the healthy development of all the parts of plants, not only the stems, but the leaves and flowers, manifest a tendency to direct themselves toward it. In the open air, the upper surface of leaves is turned toward the sky, and in a hot-house all the plants present the fronts of their leaves. Many flowers are equally sensible to light, and especially those of the *Compositæ*, such as the Dandelion, Daisy, and Sunflower, which are observed in some degree to turn themselves toward the sun. What is called the Sleep of Plants, § 218, or the folding up and drooping of their leaves at night, appears to depend chiefly upon the diminution of light; for it has been found, that some plants will unfold their leaves under the action of lamp-light. The colours of the flowers, the odorous secretions of plants, and the firmness of their texture, also depend, in a great measure, upon the supply of light.

225. Action of Electricity.—It has been observed, that plants grow with increased vigour during electrical weather; but in this case, the high temperature, and abundant supply of moisture, which accompany thunder storms, may of themselves account for the phenomenon. It has long been an opinion, that some trees are more liable to be struck by lightning than others; and this is probable enough, although it does not appear that the subject has been subjected to any strict examination. All trees, however, by the numerous points which their twigs and leaves present, are well adapted for silently drawing electricity from the clouds.

226. Action of Heat.—The great influence which temperature exercises on the development and functions of plants, is abundantly obvious. When other circumstances are equal, the vegetation is much more vigorous

in warm than in cold climates. In countries where the temperature is below the freezing point, plants cannot exist; and during winter, when the same takes place, no nourishment can be obtained by the roots, as the water in the soil is frozen. It does not appear that any natural degree of heat is injurious to vegetation, provided moisture be supplied in sufficient abundance. But all plants are not equally adapted for bearing the same degrees of heat or cold. Some grow within the influence of hot springs, of which the temperature is as high as 200°; while others are capable of resisting the severity of winter in climates where the thermometer falls to 30° or more. Most tropical plants are killed by a freezing degree of cold; and many introduced into our climates require an artificial temperature. On the other hand, many of the plants of cold climates do not thrive in tropical regions. Particular species thus have a peculiar constitution; and it has been found, that some have a higher temperature than others. It is a general law in our climates, that the temperature of trees is higher in winter than the average temperature of the air, and lower in summer; which may be accounted for, in a great measure, by their roots penetrating to a depth where the soil is always warmer than the air in winter, and colder in summer. It has been observed that some plants, at the period of flowering, emit a considerable degree of heat. This has been observed, particularly in the Arums, Senebier having observed, that the temperature of the spadix of *Arum maculatum* was 7° higher than that of the surrounding air; and M. Hubert, on placing a thermometer in the centre of twelve spadices of *Arum cordifolium*, in the Isle of France, having found the temperature to be 121°, while that of the air was only 66°.

227. Action of Air and Water.—Plants, like animals, when deprived of air, perish. It is by the action of this fluid upon their elementary organs and juices.

that materials are procured for the development of their parts, as will be subsequently explained. Atmospherical currents, by agitating the stems and foliage, promote the circulation of the sap; but when their velocity is great, frequently prove injurious, by breaking or bruising the organs. Water, being the vehicle of all the nutritious matters absorbed by plants, is essential to their existence. When it is supplied in diminished quantity, they become stunted; and when furnished in too great profusion, they acquire an inordinate development, but are unable to discharge all their functions in an efficient manner. Continued or heavy rains are injurious to the impregnation of the ovules, by washing away the pollen before it has exerted its influence. But, as in the subsequent chapters, these and other circumstances will be explained, it is inexpedient to offer any further observations on the action of water.

We now proceed to the consideration of the functions of Nutrition and Germination.

Recapitulation.

215. Have plants many properties in common with animals? What is meant by Life?—216. What are the properties of the tissues of plants? Do fluids circulate in the cellular tissue? What properties have the woody and vascular tissues?—217. Are plants possessed of Irritability? Does it differ from that of animals? What is Excitability?—218. What is meant by the Sleep of plants?—219. What plants exhibit motions on being touched?—220. Have plants spontaneous motions?—221. What are the phenomena designated by the terms Endosmose and Exosmose? Is it probable that they operate in plants?—222. Are plants acted upon by poisons, in the same manner as animals? As vegetable poisons act upon the nervous system in animals, is it proved, by the similarity of their action in plants, that the latter have a ner-

vous system? Have nerves been detected in plants?—223. Mention the principal stimulants to vegetation.—224. Give some account of the action of light upon plants.—225. What effect has Electricity upon them?—226. State some particulars relative to the influence of heat. What plants have been observed to emit heat?—227. What effects are produced on plants by the action of air and water?

CHAPTER XXI.

FUNCTION OF NUTRITION.

ABSORPTION. THE ASCENDING SAP, OR LYMPH. PROGRESSION OF THE LYMPH. EXHALATION. AERATION OR RESPIRATION.

228. FUNCTION OF NUTRITION.—We have seen that plants are furnished with roots, stems, leaves, flowers, and fruits, together with various subordinate parts; and it has been stated, § 32, that these organs may be physiologically disposed into two sets; the root, stem, and leaves being subservient to the function of *Nutrition*, the flower and fruit to that of *Reproduction*.

When the young plant is developed in consequence of germination, it extracts from the soil or the air the materials necessary for its further growth, and assimilates them, or transforms them into its own substance. This great function, which characterizes the second epoch in the life of the plant, is known by the name of NUTRITION. It includes a number of subordinate functions, which establish so many distinct periods. The plant extracts its food from the ground by means of its roots; the nutritious fluid or sap is then conveyed through the stem to the leaves; there the superfluous water is expelled; the remaining part is in the same organs submitted to the

action of the air, part of which combines with it; the sap thus altered, descends from the leaves to the roots, and is applied to the nourishment of all the organs of the plant; lastly, the portion of the sap not required for that purpose is converted into substances, intended for particular uses, or to be ejected from the plant. These subordinate functions or processes may be designated: 1. *Absorption*, or Imbibition of liquids by the roots; 2. *Progression*, or Ascent of the sap; 3. *Exhalation*, or Transpiration; 4. *Respiration*, or Inspiration and Expiration of gases; 5. *Retrogression* or Descent of the sap, or elaborated juice; 6. *Growth* of the Plant; 7. *Secretion*, or separation of substances to be retained or ejected.

229. ABSORPTION.—It was stated, § 37, that the Roots, besides fixing the plant in a commodious situation, extract from the soil, by the spongy extremities of their fibrils or radicles, the substances intended for the nourishment of the plant. The nutritious particles must be dissolved or suspended in water before they can be absorbed. Now, all vegetable tissues have the property of attracting water until they are in equilibrium as to humidity with the surrounding bodies. This action of vegetables is known by the name of *Absorption* or Suction. The leaves absorb moisture from the atmosphere, chiefly by their lower surface, and all the green parts of plants possess the same faculty; but it is chiefly by the roots that this function is performed. These organs are especially adapted for the purpose, by having the tips of their fibrils destitute of cuticle; and, as the ground is never entirely deprived of moisture, and often profusely supplied with it, a constant fund of nutritious matter is afforded. Some plants, however, vegetate luxuriantly in an arid soil, and are furnished with very small roots. They must, therefore, extract their nourishment almost exclusively from the atmosphere, which they absorb by their whole surface. This is what is especially observed in succulent plants, or those

having thick and fleshy leaves and stems; such as the Cactuses, Houseleeks, and Stonecrops. The nutritious substances of which water is the vehicle are carbonic acid, oxygen, hydrogen, and various saline, earthy, and metallic compounds.

230. CAUSES AND STIMULANTS OF ABSORPTION.—The juices existing in the plant at germination, and in the earliest stage of its subsequent development, being probably denser than the surrounding liquid or aerial media, the absorption of these media may perhaps be accounted for by endosmosis. If the tissue had the power of removing, and causing to ascend, the fluids, as fast as they are absorbed by the spongioles, we might, as Professor Henslow remarks, imagine the possibility of a supply being kept up by the mere hygroscopic property of the tissue, much in the same way as the capillary action of the wick of a candle maintains a constant supply of wax to the flame by which it is consumed. The action of the spongioles is indirectly stimulated by the atmospheric heat and light which cause the removal of a large portion of the general mass of fluid by exhalation; but light is not a direct stimulant, for plants absorb in the dark, and the roots are generally deeply buried in the soil. It does not appear that many substances, which stimulate the organs of animals, have any such effect upon the radicles of plants, which as readily absorb inert as acrid, and noxious as useful, matters, provided they be sufficiently comminuted or dissolved. It might appear from the effects of manure, that it must stimulate the roots, otherwise it might seem impossible to account for the rapid growth to which it gives rise. The elements of all plants are carbon, hydrogen, oxygen, and, in smaller quantity, nitrogen. Along with these substances are found various earthy, alkaline, and metallic substances. In animal and vegetable manures the elements of all these substances are equally found; and the rapid growth of plants, in

whose proximity they are placed, may be accounted for simply by the water in the soil becoming strongly impregnated with them.

231. THE LYMPH.—The mass of fluid imbibed by the root and other absorbent surfaces is named the *Ascending Sap* or *Lymph.* In its most simple state, it is found to be composed of water, with a little mucilage or sugar. As the two latter substances do not exist in the soil, it must be inferred that they have been produced within the plant by some chemical action upon the imbibed liquid. Of the many other substances found in plants, although in very small quantity, some suppose them to be products of the vital action of the plant itself, while others, apparently with more probability, maintain that they must have been absorbed from the soil. In the first state of the sap, the substances which it holds in solution or suspension bear extremely small proportion to the mass of water.

232. PROGRESSION OF THE SAP.—The aqueous fluid absorbed by the root, and which is much more abundant than that imbibed by the other organs, has a constant tendency to ascend towards the leaves. In the stems of dicotyledonous trees, it has been ascertained that its course is through the woody tissue, and especially the albumen or outer layers of softer wood. Its ascent takes place with great force; but there are circumstances in which its progress is accelerated, and its quantity increased, in a very perceptible degree. In general, heat increases its velocity, while cold diminishes it. In perennial plants, the sap is observed to be greatly increased at the commencement of spring, before the leaves have been developed. At this period, trees and shrubs absorb a great quantity of water, which mingles with the nutritious fluid with which all the parts are then gorged. Another period at which the sap accumulates is in August. It is to be remarked that the spring sap corresponds to the period at which the buds of the preceding year begin to unfold,

and the August sap to that at which the buds of the ensuing year begin to be formed; as if these buds, whose development is due to the afflux of sap, attracted that nutritious fluid to them, and thus accelerated its ascent. If a tree be felled in spring, the sap is found to issue most abundantly from the central parts; but it usually or often pervades all the woody parts, and may be obtained in great quantity, in certain trees, as the Birch and Sycamore, by making an incision into the outer layers of the wood. It has not been ascertained whether the sap in its progress undergoes any alteration, analogous to digestion in animals; but when a tree is tapped at different heights in spring, the fluid that exudes from the lower orifice is found to be clearer than that from the upper. This, however, may be owing to the admixture of the newly absorbed liquid with the juices previously elaborated, and deposited in the wood. When it has arrived at the extremities of the branches, it enters the leaves, where it undergoes a change which renders it fit for becoming assimilated.

233. Channels of the Ascending Sap.—There is much difference of opinion respecting the channels through which the sap is conveyed. Some observers suppose it to be propelled through the ducts or vessels, others through the intercellular or intervascular passages, while others think it passes from cell to cell by transfusion. The cause of this discrepancy is the extreme attenuation of the vesicles and tubes of the tissue of plants, and the difficulty of being convinced whether the fluids are without or within the vessels, the microscope not affording a sufficiently distinct view of the parts. Whether by the intercellular passages or by transfusion from one cell or vessel to another, the sap in its ascent tends to a lateral extension, as is indicated by its reaching the summit of a tree in which deep incisions have been made at inter---ls on different sides.

234. Causes of Progression.—The rapidity with which the sap ascends is evident from the great loss which plants often undergo from exhalation, and which must be made up by radicular absorption. A young leaf of a vine perspires so profusely in a hot day that a glass placed near its lower surface is presently covered with vapour, which soon trickles down in streams. Hales found a sunflower to lose one pound four ounces, and a cabbage one pound three ounces, a-day, by perspiration. This exhalation itself may be one cause of the ascent of the sap, although it may also be propelled by a power residing in the extremities of the roots. De Candolle supposes it to be conveyed along the intercellular passages by an alternate contraction and dilatation of the cells themselves; but of this it appears there is no proof. Hales, having cut off the stem of a vine in spring, and luted a bent tube to the top of the stump, found, by introducing mercury at the open end, that the force of the rising sap equalled the pressure of an atmosphere and a half. If a piece of bladder be tied over the surface of such a stump, it soon becomes distended, and ultimately bursts. These phenomena certainly indicate a powerful force, for which endosmosis and capillary attraction seem hardly sufficient to account. Du Petit Thouars, however, explains it on that principle. In spring, he says, when vegetation commences, the tips of the branches and the buds begin to swell; for the supply of these buds a quantity of sap is attracted from the neighbouring tissue, which is again instantly filled from that beneath it; and thus the whole mass of fluid is set in motion. He thus thinks that the expansion of the buds and leaves is not the effect, but the cause, of the ascent of the sap.

235. Transpiration.—The sap on arriving in the leaves undergoes a change, of which the first stage is a diminution of its mass by the exhalation of a great part of the water which served as the vehicle of the nutritious

substances contained in it. When the transpiration is moderate, the water on arriving at the surface of the leaf is entirely evaporated, and the process resembles that of insensible perspiration in animals; but when too large a quantity of fluid arrives at the surface, its evaporation cannot take place at once, and we then see it oozing in the form of extremely small drops at the tip of the leaf, and especially at the extremities of the nerves; several of these limpid drops often unite, and then acquire a considerable size. In this manner a large quantity of clear water is often seen collected on the leaves of the cabbage, poppy, and other plants. This water is not produced by dew, as it forms when all communication of the plant with the ambient air is intercepted by covering it with a glass, and with the surface of the ground by applying over the latter a leaden plate having a hole in the middle for the passage of the stem. It having been found that those plants exhale most which have the greatest number of stomata, § 25, and that those surfaces which are destitute of stomata produce little effect beyond what may be accounted for by ordinary evaporation, it appears evident that the stomata are the exhalant organs, and exhalation is more abundant on the under surfaces of leaves, because there the stomata are generally most numerous.

236. STIMULANTS TO EXHALATION.—If we distinguish between ordinary evaporation, which operates alike on dead and living plants, and exhalation by the stomata, we find ourselves unable to account satisfactorily for the latter, as the manner in which the stomata act is unknown. When a plant is placed in a dark room, its exhalation ceases, and when restored to the light, returns. Hence it is inferred that light is its principal stimulant. Heat also appears to affect it; at least evaporation is thereby greatly increased. Many succulent plants have so few stomata, that they may be preserved for weeks

out of the ground, without dying; on the other hand, submersed plants, which are destitute of epidermis, dry up rapidly on being exposed to the air. The water exhaled by the leaves is so pure that scarcely any traces of foreign matter are found in it. It is calculated that in general about two-thirds of the fluid absorbed by the roots are exhaled. The remaining portion, thickened and retaining the various substances originally dissolved in it, undergoes a further change.

237. Respiration. — This change results from the action of the atmosphere upon the leaves and all the other green parts of plants. During the night the leaves absorb or inspire oxygen, which combines with the carbon that has entered into the ascending sap in the state of soluble animal or vegetable matter, and transforms it into carbonic acid, which is afterwards decomposed by the action of the sun's light. During the day the leaves absorb carbonic acid and expire oxygen. This oxygen is derived from the decomposition in the parenchyma of the leaves, and through the agency of the solar light, of the carbonic acid, as well that which has been directly absorbed by the plant, as that which has been formed during the night through the action of the oxygen obtained from the air. The carbon, having thus become free in the sap, is capable of being fixed in the plant, and the greater part of the oxygen resulting from this decomposition is ejected.

238. Colour of Plants.—The green colour of plants appears to result from the decomposition of carbonic acid, and the fixation of carbon; and as this effect takes place only through the action of light, we see how great an influence that agent exercises upon the coloration and nutrition of plants. As already mentioned, vegetables which grow in darkness, are blanched, slender, and more watery and elongated than they would be, were they exposed to the sun's light. The green colour of plants, and indeed all colours, depend upon the presence of mi-

nute granules in the vesicles of the cellular tissue. The granules that produce the green tints are named *Chromule*, and are composed chiefly or entirely of carbon. The parts of plants which are coloured otherwise than green, do not assimilate the oxygen of the air, but whether by day or by night, this oxygen combines with a part of their carbon which is superabundant, and thus reproduces carbonic acid.

239. Effect of Respiration on the Atmosphere.—Plants vitiate the air around them, because their green parts inspire by night a certain quantity of oxygen, which they do not entirely restore by day, and because the parts which are not green form carbonic acid at the expense of their proper substance. On the other hand, plants purify the air by decomposing the carbonic acid formed within them, and that which they absorb dissolved in air or water. The ultimate effect of vegetation plainly consisting in an increase of the mass of carbon fixed in plants, and carbon arriving in them only through the decomposition of the carbonic acid of the air, it is clear that vegetables, considered in a general sense, tend to diminish the quantity of carbonic acid in the atmosphere, and to increase that of oxygen. But the respiration of animals and combustion tending to produce just the contrary effect, the general stability of the constitution of the atmosphere is not perceptibly disturbed.

The sap altered by respiration in the leaves and other green parts, now descends into the stem and root, and is rendered subservient to the development of all the organs.

Recapitulation.

228. What are the two principal functions of plants, and the organs by which they are performed? Give a general ac-

count of the function of Nutrition, and enumerate its various stages?—229. What is meant by Absorption? By what organ is it chiefly performed? What other parts of plants imbibe moisture? How are succulent plants, which grow in dry sand, nourished?—230. How may endosmose act in producing absorption? What effects have heat and light upon absorption?—231. What is the Sap? Of what is it composed? How are the various substances found in it supposed to be introduced or generated?—232. What becomes of the fluid absorbed by the roots? At what periods of the year is the sap most abundant? Is there any difference in the quality of sap obtained at different heights in trees? What becomes of the ascending sap?—233. Through what channels is the sap conveyed?—234. What are the causes of its progression?—235. What change is first undergone by the sap on its entering the leaves? When the transmission of sap into the leaves is very rapid, what happens? How is it proved that the drops on leaves are not produced by dew? How does it appear that the stomata are the exhalant organs?—236. What circumstances are favourable to exhalation? Are succulent plants more readily dried? What proportion of the sap is exhaled?—237. What is the action of leaves on the atmosphere at night, and by day? What results from this action with regard to the sap?—238. How is the green colour of plants produced? What is Chromule?—239. How does vegetable respiration affect the state of the air? What effect has the respiration of animals upon it?

CHAPTER XXII.

NUTRITION—(*continued*).

THE ELABORATED OR DESCENDING SAP. ITS PROGRESS DOWNWARDS. VEGETABLE SECRETIONS. ASSIMILATION.

240. Elaborated Sap.—The sap, deprived of its superabundant water, and altered by the action of the air, has been converted into a fluid capable of being assimilated to the various parts of the plant, and consequently of directly affording them nourishment. It then forms what has been called the *Nutritious Juice*, *Proper Juice*, *True Sap*, or *Descending Sap*. In this state it contains a large proportion of gum, sugar, or fecula, and is further submitted to modifications resulting in the formation of various substances, either to be retained or separated as useless. Owing to the manner in which the juices are intermixed, and on account of the great number of vegetable products contained in them, it seems impossible to determine the true nature of the elaborated sap. All these products are composed merely of different modifications of the same elements, namely, carbon, oxygen, and hydrogen; but the fluids of different species of plants present great differences in their palpable qualities; so that no particular modification can be assumed as the general sap, analogous to the blood in animals. In some plants it is a white and milky juice, in others yellowish, in many limpid; and its properties are equally various.

241. Descent of the Sap.—The principal movement of the elaborated sap is in the inverse direction of that of the lymph or fluid absorbed by the roots. If a tight ligature be applied to the trunk of a dicotyledonous tree,

or a ring of bark removed from it, the nutritious juices being unable to descend, accumulate above the ligature or ring, and there form a circular swelling, which becomes more and more prominent. It is further remarked, that the part of the trunk situated beneath the ligature ceases to grow, and that no new woody layer is added to those already existing, because the nutritious fluid is unable to reach it. This fact therefore proves, that it is to the descending sap that the growth of the plant is due. It circulates chiefly in the parts of the stem in which new layers are formed, or along the bark and alburnum. It covers the inner surface of the former, and the outer surface of the latter, with a fluid, which becomes more and more viscid, and then takes the name of *Cambium*. Presently traces of organization appear in this fluid, and there form in it new cellules and fibres, which gradually acquire consistence. This, as has been stated, is the mode of growth in the trees of our climates; but it does not appear that any thing is known with precision regarding the descending sap in the stems of monocotyledonous trees.

242. Peculiar or Local Movements.—The ascending sap and the descending sap cannot be supposed to be strictly confined within certain limits, as the organs through which they pass are contiguous, and, in whatever way it may be accomplished, a transfusion or lateral movement takes place. In the cells of certain plants, especially those of the Genus *Chara*, a circular movement of the fluid, rendered observable by the existence of opaque granules in it, is observed, the granules ascending by one side of a cell and descending by the other. Another kind of circulation was discovered by M. Schultes, who describes the proper juices of many plants as undergoing a complex kind of motion, in particular vessels, which occur in the root and stem, and appear to anastomose in their whole extent.

243. VEGETABLE SECRETIONS.—The descending sap is not merely subservient to nutrition, but furnishes various matters which are secreted or separated from its mass, and afterwards elaborated by particular organs. Many of these matters are ejected, and constitute what are called *Excretions*. Whether they are to be considered as components of the sap, or secretions from it, there are four substances, closely allied in chemical composition, which are of very general occurrence: gum, sugar, fecula, and lignine.

Gum is a substance destitute of taste or smell, insoluble in alcohol, but forming with water a viscid fluid to which the name of mucilage is given. It is observed in various parts of plants, as the seeds, bark, and roots. The purest kinds are gum-arabic and gum-tragacanth.

Sugar is a substance having a sweet taste, and soluble in water, as well as more sparingly in alcohol. It is met with in most parts of plants. Several kinds are distinguished. That in common use as an article of food is obtained from a species of grass, the Sugar Cane, by expression and evaporation. The sugar of the beet-root, chestnut, and maple, is similar. When pure, this sugar crystallizes in a regular manner, and then forms candy sugar. Grape sugar, which is extracted from the grape, gooseberry, apricot, and fig, has a different taste, and contains more water.

Fecula or *Starch* is a substance composed of organic granules, which is extracted by trituration in water from the roots, tubercles, and stems of various plants, and chiefly from the seeds of wheat, barley, oats, and other cereal grasses. Each granule is formed of a membranous covering, and an inclosed substance of a gummy appearance. The fecula is deposited at the bottom of the water in the form of a white shining powder, destitute of taste or smell. It forms a mucilage with boiling water, and if the solution is evaporated a kind of jelly is obtained.

Lignine, which is also composed of granules, having an external pellicle, is contained in the elongated cells or vessels of the woody tissue of plants, and does not appear to answer any other purpose in the vegetable economy, but remains unchanged in the cells. It differs from gum, starch, and sugar, chiefly in containing a larger proportion of carbon.

244. OTHER VEGETABLE PRODUCTS. — Besides the above four substances, which appear to be the simplest modifications assumed by the nutritious materials found in plants, there are many others, of which the more remarkable are here mentioned. The *Fixed Oils* are combustible substances, insoluble in water, and forming soaps with alkalies. They occur in the fruits, and chiefly in the seeds of various plants, and are divided into such as thicken and become opaque when exposed to the air, as olive oil and oil of almonds, and such as dry without losing their transparency, like varnish, as linseed-oil. Vegetable *Wax* differs from fixed oil only in being solid at common temperatures. It is seen on plums, oranges, and the leaves of the cabbage, in the form of a very fine glaucous powder; on the fruit of Myrica cerifera and the trunks of some palms, in a thick layer; and preserves plants from the injurious action of moisture. *Volatile Oils* are much more common, and are met with in the bark, leaves, flowers, and pericarps of plants. They resemble the fixed oils, but are distinguished from them by a strong smell, a slight solubility in water, and the property of being volatilized without decomposition. They are used in painting or as perfumes. Most scented substances or aromas owe their properties to these volatilized oils. They are found in the bark of the cinnamon, the leaves of the Labiatæ, such as Mint and Thyme, and the rind of oranges and citrons. *Camphor*, which is nearly allied to the Volatile Oils, is a solid, colourless, transparent, highly odorous, and inflammable substance,

obtained by distillation from the wood of certain species of Laurel.

245. VEGETABLE PRODUCTS, continued.—The *Resins*, are dry, brittle substances, insoluble in water, soluble in alcohol, softened by a low degree of heat, and highly inflammable. Resins mixed with volatile oils and benzoic acid form the *Balsams*, which are inflammable and odorous. Of the former may be mentioned the resin of the pines, mastic, dragon's-blood, and copal; of the latter benzoin, storax, and balsams of Peru and Tolu. *Caoutchouc* or *Elastic Gum*, which flows in the form of a milky juice from several trees of the equatorial zone, is neither a gum nor a resin, but a peculiar substance which is insoluble in water and alcohol, coagulates in the air, becomes brown, assumes the appearance of leather, and acquires an extreme elasticity. Plants contain *acid* principles, and others possess *alkaline* properties. The most remarkable vegetable acids are *Acetic Acid*, or pure vinegar, furnished by the fermentation of various liquors, and the distillation of wood; *Malic* and *Citric Acids*, which are extracted from fruits, and particularly from the apple and lemon; *Oxalic Acid*, which is found in the leaves of oxalis, in combination with potash; *Tartaric Acid*, which occurs in the free state in the pulp of certain fruits, and in combination with potash in the juice of the grape, when it forms cream of tartar; *Prussic Acid*, a very active poison, which is extracted from bitter almonds, and from the kernel of the peach, apricot, plum, cherry, and other drupes; *Gallic Acid*, which produces a black colour, with red oxide of iron, and is found in gall-nuts, and in most barks of trees, communicating its astringent property to most of the vegetable substances which contain it, among others to the tannin used for preparing leather. Of the alkaline substances may be mentioned *Morphine*, which is contained in opium, or the juice extracted from the white poppy, and of which the salts formed by its combi-

nation with acids, especially acetic acid, are very dangerous poisons, and *Quinine*, which is extracted from Cinchona. Plants, moreover, contain various colouring matters, which are found sometimes in the roots, as madder; sometimes in the stems, as the colouring substance of Brazil wood; sometimes in the leaves, as indigo; or in the flowers, as the red of Carthamus.

246. ADVENTITIOUS SUBSTANCES IN PLANTS.—Besides the numerous products of Secretion, resulting directly from the action of the elementary organs, there are substances which have been absorbed by the roots, or have resulted from the combination of these substances with the vegetable products. *Lime* is generally found in the ashes of plants, in the form of a carbonate, or in union with various acids. *Silica* also occurs in considerable abundance, especially in the stems of some monocotyledonous plants. The glossy pellicle on the surface of reeds, canes, and other grasses contains a large proportion of it, insomuch that if two canes be rubbed against each other in the dark, they emit a light like that given out by the friction of two pieces of quartz. On the inner surface of the fistular joints of the Bamboo, a substance named *Tabasheer* is deposited, in plates or masses, at first moist like paste, but ultimately resembling semitransparent disintegrated opal. When a stack of corn has been burnt, the ashes are found fused into a partially vitrified mass, resulting from the silica and alkali contained in the straw. Salts of *potash* and *soda* are abundant in many plants, those of the latter in such as grow near the sea. Common Soda or Carbonate of Soda is obtained by burning several maritime plants, as *Salsola Kali* and *Salsola Soda*, as well as marine algæ, such as *Fucus vesiculosus and Fucus serratus*. These substances are so abundant in plants that they can hardly be considered as merely adventitious; but various other products, such as metallic oxides and salts, that occur in small quantities in the

ashes of plants, have probably been derived from absorption by the roots or leaves.

247. EXCRETIONS.—Many of the substances above enumerated are to be regarded as excrementitious, especially wax, which is found on the surface of fruits, gums, and resins, which exude from the bark, volatile oils and glutinous juices. Stinging plants, as Nettles, secrete an alkaline caustic juice, contained in a cellular bag, surmounted by a hollow bristle. When the bristle is pressed, the fluid passes through the tube, and is ejected into the wound, by a mechanism precisely similar to that of the poison-fangs of serpents. Clammy substances are often secreted on the stems by glandules or glandule-tipped hairs. Among the most remarkable excretions are those discharged from the roots of plants, it being found that some give out acid, others milky, mucilaginous, or saccharine substances. It has been suggested by M. De Candolle that the theory of the succession of crops is to be sought for in this circumstance. It had been observed that some plants will not prosper in situations where others of the same kind had previously grown, and that certain plants succeed best when sown in ground previously occupied by certain other species. Now, among the substances which act as poisons to plants, it has been found that most vegetable secretions are to be enumerated, and it is a general law that no plant is capable of digesting its own excretions. But, although the excretions of a plant may be noxious, not merely to its own species, but to others of the same genus or family, they may be harmless or even beneficial to plants of other families. It seems thus probable that by a proper rotation of crops, the soil might be preserved in a state of fertility, without the application of much manure.

248. TASTE AND ODOUR OF PLANTS.—The tastes of plants must depend upon the nature of their juices and the substances secreted from them. This subject, how-

ever, has received little attention, and the classification and nomenclature of tastes, as well as of smells, is merely empirical. Some parts or substances are tasteless, or nearly so, as membrane, mucilage, and resin; sweet tastes depend upon the presence of sugars; sour, upon that of acids; bitter, upon alkaline salts or extractive matter; astringent, on acids in excess; acrid, on volatile oils. The odours of plants depend chiefly upon the emission of an essential oil, which differs in the different species, being more or less volatile, and in various degrees miscible in water. The oil is stored in the stems and leaves, and when these parts are rubbed or bruised the odour becomes more sensible. Heat generally renders the odours of plants more powerful, but sometimes dispenses the odorous particles so rapidly that little smell is apparent. Some flowers emit their odour only in the evening or at night, as is the case especially with those Cruciferæ, as the Wall-flower, that have a dingy brown colour. The nomenclature of scents is not more intelligible than that of tastes: sweet, aromatic, musky, fetid, alliaceous, acrid, nauseous, oppressive, and the like. Very different impressions are made on different individuals by the scent of the same flower. Some odours make very deleterious impressions on persons of weak nerves, insomuch that death has sometimes resulted from them.

249. Assimilation.—The sap having been elaborated and conveyed to the different parts of the plant, is applied to the nourishment and development of its various organs. But of the manner in which this assimilation of the nutritious fluid takes place, it appears that nothing is known with precision. How the first cellules of the elementary tissue are produced, and in what manner they are increased or extended, have never been satisfactorily determined; for the various organs already exist in some degree of development before we can submit them to examination, and their extension cannot be

traced in continuance with the necessary minuteness and attention. The processes already described and that of assimilation go on simultaneously, and although we are sensible of the general results, we are unable to trace the progress of the parts in detail. Some suppose the tissue to be extended by the development of young cells within the old ones, which they rupture and replace; others think that the new cells originate from the minute granules or dots seen on the surface of some cells; and others are of opinion that the cells become divided by transverse partitions, the space between each pair of which becomes a new cell. The vascular tissue is supposed by some to be similar in origin to the cellular tissue, the vessels being merely elongated cells, or series of united cells. Others consider the new vessels as analogous to roots, and maintain that they proceed from the buds placed in the axillæ of the leaves. Some parts of plants once formed appear to be incapable of receiving further development. Of this kind is the pith, which is enclosed in a cylinder of tissue that prevents its extension. The woody layers also remain stationary, the only change effected upon them being the filling up of their cavities by the deposition of lignine and other substances. It appears to be by the cellular or parenchymatous tissue that the development of plants chiefly takes place. The pith, then filled with fluid, is the first part that appears when the stem shoots up. Scales, young stamens, and pistils, and the tips of the radicles, are composed of it; in all cases of wounds, as in pruning, propagating by slips, or grafting, it is the part first generated.

250. PRUNING.—When a limb or branch is cut off for the purpose of improving the timber of the stem, or for giving the plant a more agreeable form, a portion of the inner parts of the woody layers is exposed. These being incapable of generating new tissue, would remain exposed, and decay, were it not for the newer tissue

round the edge of the wound, which gradually extends over its surface so as to meet in the centre, forming a complete cicatrix. In dicotyledonous trees and shrubs, as has already been stated, the growth takes place at the part where the outer layer of wood and the inner layer of bark are in contact. Now, in the case adduced, the wood covered over by the extension of the parenchymatous tissue of the bark produces no new layer, and the layer of wood formed over it does not adhere to it. As the growth of the tissue that covers the wound depends upon the returning sap for its nourishment, the branch must not be lopped at a distance from the trunk, otherwise it will not heal over, there being no leaves upon it to furnish a supply of elaborated sap, and whatever descends from the stems is expended in developing the tissue and lower parts of the stump of the amputated limb. Since the surface of the cut never adheres to the new tissue formed over it, and the wood is always more or less blemished by pruning, it is obvious that the operation should be performed when the branches are young, or even when only in bud; but if this cannot be done, the cut should be made quite close to the trunk, and its surface protected by some compost to prevent any degree of decomposition until it is healed over.

251. Grafting.—The operation of grafting also shews the superior vitality of the parenchymatous tissue, and proves that the nutritious fluid circulates in the more external parts. The object of this process is chiefly to propagate particular varieties of fruits, which cannot be obtained from seed. A bud or twig of the tree to be propagated is united to another tree on which it grows, the fruit produced continuing to be similar to that of the original tree, and not of the stock on which it has been placed. This kind of union takes place between individuals of the same species, between species of the same genus, or between species of different genera of the same

natural family, and the more nearly the two species are allied, the more ready are they to unite. The operation is performed in various way. When the branches of two or more trees are united, it is called *Grafting by approach.* Usually in this case two plants are placed near each other, and their branches grafted. When they have become perfectly united, one of them is separated from its stem, and left to grow on that of the other. Another way is to cut a shoot from a tree, and attach it to the extremity of the branch of another tree prepared for the purpose by being cleft or otherwise cut. This is called *Grafting by slips.* A common practice also, called *Budding*, is to remove a bud along with a portion of the surrounding bark, cut out a corresponding piece from another tree, and insert the bud in its place. In all cases the albumen and liber of the two trees must be placed in correspondence. The graft is secured from displacement or access to air for some time, and complete union takes place. In this manner are multiplied different kinds of fruits, as apples, pears, and plums, each of which is only a variety accidentally raised from seed, but is not capable of being further propagated in the same way. It is thus apparent that in dicotyledonous trees the principal seat of the vital operations is in the liber, alburnum, and intervening cambium. Two of the theories which explain the growth of these trees may here be mentioned. One of them, of which the author is M. Du Petit-Thouars, attributes the successive formation of the woody layers to the development of the buds; the other, or M. Mirbel's theory, to the cambium.

252. Du Petit-Thouars' Theory.—The considerations upon which this theory are founded are the following: —Buds are the first perceptible phenomena of vegetation; there is one in the axilla of each leaf; but it is only on Dicotyledonous Plants, and in the Gramineæ, that the buds are apparent, they being in other plants

latent, and consisting merely of a vital point, which, in certain circumstances, is capable of being developed. Buds, by their development, give rise to shoots, which are furnished with leaves, and generally with flowers. Each bud is, in some measure, independent of the rest, and may be considered as analogous to the embryo of a seed. Buds may thus be called *Fixed Embryos*, in opposition to seeds, which are *Free Embryos*. If we examine the interior of the buds on a shoot or young branch, we find that it communicates directly with the pith, which is at first green, and filled with sap, from which the buds derive the first materials of their development. Having thus supplied the buds, the internal parenchyma dries up, and becomes converted into pith properly so called. As soon as the buds appear they obey two general motions, an ascending and a descending, being in this respect similar to the seeds. The layer of cambium, situated between the wood and the bark, is analogous to the soil in which the seed grows. The bud sends upwards a shoot or young branch, and downwards into the cambium fibres, or radicles, which, gliding between the liber and alburnum, descend to the lower part of the plant. In their course downwards these fibres meet those which descend from other buds, unite with them, anastomose, and thus form a layer, which acquires consistence and solidity, and forms each succeeding year a new woody layer. The liber, once formed, does not change its nature, and undergoes no transformation. This theory, which is very ingenious, and remarkably simple, has not been generally adopted.

253. Mirbel's Theory. — If we examine a young branch at the period of vegetation, we find between the liber and alburnum a layer of fluid, at first limpid, but gradually thickening and acquiring consistence. This fluid, the *Cambium*, is the descending sap, mixed with part of the proper or secreted juices. As it thickens, filaments are seen to form in it, and it gradually assumes

the appearance of vegetable tissue, the development of the layer continuing during the whole period of the development of the buds. In this manner, a new layer of woody tissue is formed each year in the trunk of dicotyledonous trees, being produced by a part of the cambium, which is organized, and becomes solid. The alburnum formed the preceding year acquires more density, and changes into wood properly so called. A thinner layer, also formed from the cambium, is added to the liber or inner bark. This theory is the one most generally adopted by writers on vegetable physiology.

254. Continuance of Growth.—Although an apparent cessation of the development of plants takes place in winter, after the leaves have fallen, yet even during that season some slight enlargement of the buds is observed, and the sap is not entirely quiescent. When spring advances, the increased temperature gives a continued impulse to the vital powers; the sap flows with rapidity towards the twigs, and the buds are quickly developed. As the summer advances, the motion of the fluids gradually diminishes. In autumn, the buds which have been formed in the axils of the leaves continue to grow, while the other herbaceous parts decay; and thus there is caused a renewed, but less vigorous, motion in the sap, which ceases as the cold increases. As the fluids are in a state of torpidity, and the development of the parts arrested, in winter, trees or other vegetables may, at that season, be transplanted with less injury than at any other.

Recapitulation.

240. What names are given to the elaborated juice? Are its general characters easily defined? Does it vary in its qualities?—241. What course does the sap now take? How may its descent be proved? Where does it chiefly circulate?

What is the Cambium? What changes take place in it?—242. Does the descending sap follow a strictly defined course? What motions are observed in the cells of Chara? What kind of circulation has been seen in the proper juices?—243. What are the substances most generally found in the sap? Give an account of Gum. What are the characters of Sugar? Describe Fecula. To what use is Lignine peculiarly applied? —244. Mention some other vegetable products. What are the general characters of the Fixed and Volatile Oils? Mention some plants that produce Wax. How is Camphor obtained?—245. What is the nature of Resin? Describe Caoutchouc. What are some of the most remarkable vegetable Acids? Mention some Alkaline Substances. In what parts are Colouring Matters contained?—246. What adventitious substances are contained in plants? What is Tabasheer? Do many plants contain Potash? In what kinds is Soda found?—247. What substances may be considered as excrementitious? How do the excretions of the roots of plants account for the rotation of crops?—248. Upon what do the tastes of plants depend? What is the principal cause of their odours?—249. How are the elaborated juices applied to the development of the organs? Mention the three different opinions regarding the development of the cellules. How is the vascular tissue supposed to be formed? What parts remain stationary after being formed? On what tissue does the growth of plants chiefly depend?—250. What is meant by Pruning? What takes place when a branch is cut from a tree? Should branches be cut off short, or at some distance from the trunk? —251. What is Grafting? Describe its three principal kinds. What parts must be placed in correspondence? What results?—252. What is the Theory of Du Petit Thouars with regard to the growth of Dicotyledonous trees?—253. State the Theory of M. Mirbel on the same subject.—254. Is the progress of vegetation entirely arrested during winter? At what season may vegetables be transplanted with least injury?

obtained. Many plants, as elms and poplars, throw up suckers from their roots, at some distance from the trunk, which, under favourable circumstances, may become distinct trees. But although many plants may be propagated by these methods, all those which produce flowers secure the continuation of their species by a different process.

257. Reproduction.—By *Reproduction*, properly so called, is meant the formation of seeds, containing the germs of new individuals. To this function are subservient the Perianth, Stamens, and Pistils, § 32, 130. A seed is a germ or embryo, which having been formed upon the parent plant, and for some time derived its nourishment from it, has become free, after being fecundated, or in other words after receiving the principle of life, or the power of becoming developed under particular circumstances. The seed, which separates from the parent plant, is furnished with proper envelopes and with organs of nutrition. It is not, like the bud or bulbil, a continuation of the same individual; but a new individual resembling that from which it has been derived only in the parts essential to the species. Reproduction by means of seeds comprehends several distinct periods or processes: *Floration*, or the development of the flower; *Fecundation*, or the act by which the pollen, having become attached to the stigma, imparts life to the ovules or rudimentary seeds contained in the pistil; *Maturation*, or the passage of the ovary into the state of perfect fruit; and *Dissemination*, or the dispersion of the ripe seeds.

258. Development of the Flower.—The causes of the production of Flowers are unknown. Some plants flower in a few weeks after germination, others take some months, and others require several years. Flowers are not, as was long supposed, mere ornaments to plants, for they contain the organs essential to reproduction, namely, the stamens and pistils. When first distin-

guishable, their parts are in a rudimentary state, especially the perianth, which for some time continues to enlarge much less rapidly than the stamens. All the organs, however, gradually enlarge until expansion takes place. In the bud, the calyx usually covers and protects the other parts, the corolla is generally closed over the stamens and pistils, the anthers are developed, and burst at the period of expansion, or presently after.

259. STIMULANTS TO FLOWERING. — The period of flowering is accelerated by an increase of temperature, and retarded by cold. These causes also operate in determining the buds to assume the character of leaf-buds or flower-buds. Superabundant moisture retards the flowering, and renders the flower-buds less numerous, as in the case with a too profuse supply of nutriment, or an unusual excitement by heat; whence the fruit-trees of temperate climates, on being carried to the tropics, often vegetate vigorously, although they become barren. It seems to be a general law that the number of flowers produced by a plant is in some measure proportional to the quantity of nutritious matter which it has accumulated. Thus, after a warm and bright summer, during which the branches have acquired only a moderate development, and nutritious matter has been stored up, a profusion of flowers is produced.

260. PERIODICITY OF FLOWERING.—Different species flower at different periods of the year, varying to a considerable extent, however, according to the state of the weather, and the degree of temperature. Thus, the Christmas Rose flowers in January, the Snowdrop in February, the Crocus in March, the Primrose in April, the Lily of the Valley in May, the Wood-Vetch in June, the Yellow Iris in July, the Tansy in August. The reasons of this variation we are unacquainted with; and, when we attribute it to the peculiar character of the species, we merely use words to conceal our ignorance.

Owing to some peculiarity in the constitution of individuals, they flower earlier or later than others of the same species; and in both cases, advantage is taken of the circumstance by propagating peculiar races, which afford the cultivator a longer succession of crops. After producing a very abundant crop, which has exhausted the nutritious matter prepared in the stem, few flowers are produced the next season; and thus, apple and pear trees usually have alternate years of productiveness and comparative sterility. Many plants, as the Elm and Alder flower, before producing leaves; but the greater number after. Sometimes, when the leaves have been destroyed in summer by drought or insects, a second crop of flowers is produced in autumn.

261. HORARY EXPANSION OF FLOWERS.—The flowers of particular species open at certain periods of the day, some in the morning, others at noon, and others in the evening. Most plants, however, appear to have no determinate period in this respect, their flowers, when once expanded, continuing open until they decay. Linnæus named *Ephemeral* those flowers which open at a particular time, and wither in the course of a day; and *Equinoctial*, such as open and close several days in succession at the same hour, some of them being diurnal, and others nocturnal. He constructed tables, which he fancifully termed *Flora's Time-pieces, Horologia Floræ,* to shew the hours of expansion of various flowers. Thus:

Tragopogon pratense, opens from	3 to 5.
Papaver nudicaule, . . at	5.
Hypochæris maculata, .	6.
Nymphæa alba, . . .	7.
Anagallis arvensis, . .	8.
Calendula arvensis, . .	9.
Arenaria, ...	9, 10.
Mesembryanthemum, . .	11.

262. FUNCTIONS OF THE PERIANTH.—The calyx and

corolla, when present, obviously serve to protect the sexual organs. The petals usually fall off before the fruit is matured, but the calyx often remains, enlarges, and covers the pericarps. Sometimes the perianth forms appendages of various kinds to the fruit, as in the *Compositæ*, where the calyx constitutes the pappus or seed-down. As no part of a plant can be intended merely for ornament, the corolla must answer some important purpose with reference to the production of the seed; but the functions of the perianth are little known, and as it is sometimes absent, it is imagined by some to be in a manner unessential, although even in such cases it may be substituted by the glands or other parts. It has been conjectured that the petals and nectaries secrete a fluid intended for the nourishment of the anthers and ovules; and this process has been compared to that of germination, to which it bears a further analogy by the development of heat. This phenomenon is most remarkable in some Arums, as has already been mentioned, § 226.

263. Fecundation.—When the flower has attained a certain degree of development, the pollen formed by the anther falls upon the stigma, and thus causes the fecundation of the ovules contained in the ovarium or lower part of the pistil. It is easy to prove that the action of the pollen upon the pistil is absolutely necessary for the fecundation of the ovules and the production of the seeds which are developed in that organ. Thus, it is enough to remove the stamina from a perfect flower to render it sterile, provided it be at a sufficient distance from other flowers, of which the stamens have not been removed; and when a flower has been thus mutilated, it is enough to throw upon its stigma some pollen taken from another flower of the same species, to make it produce seeds as usual. In monœcious plants, that is in such as bear on the same stem flowers that have stamens only and flowers that have pistils only, such as the maize or Indian corn,

if the staminiferous flowers be removed, the rest will be prevented from producing seed; and in diœcious plants, or such as have flowers with stamens on one stem, and flowers with pistils on another, the fecundating action of the pollen is still more evident. It has been known to the people of the East, from time immemorial, that the Date Palm, which is diœcious, will not perfect its fruit unless some of the staminiferous individuals are cultivated in the vicinity of the fruit-bearing trees, or unless bunches of the male flowers should be suspended near them. In Egypt and other eastern countries, the female trees only are cultivated, and bunches of the male flowers are brought annually from the deserts. It is stated that when the French were in Egypt, in 1800, the inhabitants were prevented from procuring the blossom, and a general defect of the date crop ensued. Another proof is derived from the production of *hybrids;* for if the stamens of a flower be removed, and its pistil impregnated with the pollen from another plant of a different species of the same genus, the seeds will be matured, and on germinating will produce plants having characters intermediate between those of the two species. It is thus obvious that the stamens and pistils are the sexual organs of plants.

264. Sexes in Plants.—The distinction and uses of the stamens and pistils were even in some degree known to various individuals before the time of Linnæus, who, however, was the first to demonstrate in a satisfactory manner the sexes of plants, or at least, to bring the subject more particularly into notice, by employing the sexes as the basis of his classification. However, the existence of stamens is not necessary in all plants to produce the germs of new individuals, for in Ferns, Lichens, Fungi, and other flowerless plants, male and female organs are not discoverable. It has been alleged, too, that Hemp and Spinach sometimes produce fertile

seeds without the contact of pollen; but even should this occasionally be the case, it would not militate against the general law, for in these diœcious plants some male flowers might exist among the female, and the pollen is often wafted by the winds to almost incredible distances. Thus, it is said that in 1805, a female date palm at Brindes, which regularly flowered, but never bore fruit, was fecundated by a male plant of the same species, thirty miles off at Otranto, which had then only attained a sufficient height to overtop the trees in its neighbourhood, and thus allow its pollen to be dispersed.

265. Formation of Pollen.—The cells of the anthers are at first filled with a mass of cellular tissue, in each vesicle of which are one or more grains of pollen. These grains gradually enlarge, and at length rupture the vesicles, when the remains of the cellular tissue form loose shreds or fibres intermixed with the pollen. Each grain is generally composed of two membranes, of which the outer presents various appearances, while the inner is an extremely delicate pellicle. The granules, which it contains, are of various forms, being spheroidal or cylindrical. The grains themselves appear to have no attachment to the walls of the anther, and the granules in the fovilla often exhibit a rotatory motion.

266. Protection of Pollen.—When matured pollen is placed in water, it presently dilates, bursts, and emits a mass of granules. It is therefore necessary that it should be protected from moisture. In many cases the anthers are matured before the corolla opens, as is the case especially in all the Compositæ. Plants that grow in water elongate their peduncles until the flowers reach the surface, where they float, as in *Nymphæa*, or emerge to a considerable height, as in *Alisma*. In *Zostera marina*, the flowers, although developed under water, are placed within a cavity filled with air, and are thus efficiently protected. Perhaps the most remarkable instance

of this protection of the pollen from the action of water, is that exhibited by an aquatic plant, *Valisneria spiralis*, a native of the south of Europe. It is diœcious, and grows at the bottom of the water. The female flowers are borne on peduncles several feet long, and twisted in a spiral manner, which allows them to be elongated or shortened. The male flowers, on the contrary, have very short peduncles. At the period of fecundation, the female flowers ascend to the surface of the water to expand, the male flowers detach themselves from their peduncles, expand at the surface, around or intermingled with the female flowers. Soon after fecundation is effected, the female flowers, by the contraction of their peduncles, are drawn back into the water, and there perfect their seeds.

267. Dispersion of Pollen.—When the pollen is matured, it bursts the anthers, escapes, and is scattered around. The stigma, which is adapted for receiving it, by being moistened with a clammy fluid, or furnished with filaments, is so placed, with reference to the anthers, as to ensure the pollen falling upon it. Thus, sometimes when the pistil is much longer than the anthers, the flower droops; when it is shorter or equal, the flower is erect. Some flowers incline upwards, others downwards, when fecundation is about to take place, so as to put the stigma in a proper position for receiving the pollen. To favour the emission of the pollen, and its reception by the stigma, the fecundating organs perform very remarkable motions. Frequently the anthers open by the side of the pistil, with a kind of explosion, and thus cast the pollen upon it; the stamens sometimes approach the pistil at the time of emission, or bend their filaments so as to place the anthers over the stigma; or the pistils themselves incline toward the stamens. Numerous other contrivances contributing to the same general effect might be mentioned. The pollen is dispersed partly by the elasticity of the anthers in bursting, partly

by its weight, and partly by the action of the air. In diœcious plants especially, when the male plants are often placed at a great distance from the female individuals, the dispersion is operated by the winds. Dry weather is necessary for the free dispersion of the pollen, and sometimes, when the rains are heavy and continued, the process is rendered defective.

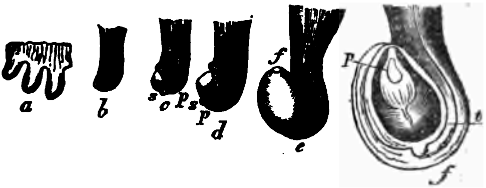
268. Action of the Stigma.—The grains of pollen which have fallen upon the stigma adhere to the glutinous fluid with which it is covered. After they have remained for some time there, the outer coat of each grain bursts, and the granules, contained in the delicate inner membrane, are protruded. This membrane, now termed the *pollen tube*, contains, as has been stated, a liquid, the *fovilla*, in which are numerous pollen-*granules*. The pollen tubes penetrate between the vesicles of the cellular tissue of the stigma, rapidly increase in length, extend, down the style, make their way into the cavity of the ovarium, run along the placenta, and surround the ovules. What further action takes place, or in what manner the pollen tubes, or their fovilla or granules, act upon the ovule, are unknown. Presently, however, the ovules begin to increase with rapidity, and the fruit swells.

269. Maturation of the Fruit.—When fecundation is accomplished, the nutritious fluids which were equally distributed among all the parts of the flower cease to supply the stamens, then the corolla, often also the styles, and the calyx. The stamens and corolla thus shrivel and fall off, as do the style and stigma, and in many cases the calyx. The ovarium, to which the fluids are now exclusively directed, becomes developed, and assumes the name of *Fruit*. From the time when it thus begins to enlarge, until the seeds are perfected, is the period of *Maturation*, or of *Fructification*, properly so called.

270. Development of the Ovules.—When the *Ovules* are first seen, they are small protuberances arising from

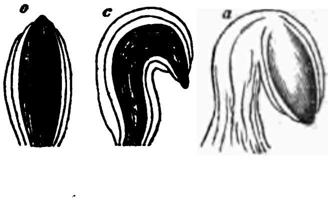
the surface of a cavity in the ovarium, and present no distinct traces of organization, Fig. 14, *a*. Soon after they elongate, *b*, *c*, *d*, and are found to consist of an internal part, or *nucleus*, composed of cellular tissue, and of *two coats*, *p*, *s*, by which the nucleus is partially invested. These coats gradually extend, so as at length to cover the nucleus, leaving only a small orifice, named the *Foramen*, *e*, *f*. The outermost is named *Primine*, the inner *Secondine*. The nucleus itself is composed of two, sometimes three sacs; the outer, or *Tercine*, *f*, *t*, thick and fleshy, the inner, or *Quartine*, *q*, delicate.

Fig. 14.



As the ovule enlarges, it changes its position. The apex, which at first was on the side of the ovule opposite the part by which it is attached to the ovary, is brought close to its base. The place at which the secundine is attached to the primine, and which is named the *Chalaza*, *z*, is distinct from the place where the *podosperm* or *funiculus* is attached to the primine. The vascular tissue which passes through the podosperm extends through the substance of the primine, from the hilum to the chalaza, forming a

Fig. 15



fasciculus named the *Raphe.* When the hilum and chalaza are contiguous, and the foramen at the other extremity, the ovule is said to be *Orthotropous*, Fig. 15, *o.* This is the case with all ovules in their earliest stages. When a greater development of the integuments and nucleus takes place on one side than on the other, the ovule becomes bent, and is said to be *Campulitropous*, *c.* When the chalaza is distant from the hilum, so that the position of the ovule is reversed, it is named *Anatropous*, *a.*

271. Progress of the Seed.—Soon after the pollen-tubes have passed down the stigma into the ovarium, the embryo makes its appearance, as a minute vesicle, affixed to the top of the embryonic sac, with its radicle directed towards the foramen, and the cotyledons directed towards the chalaza. All the parts of the ovule gradually increase; the primine and secundine lose their juices, and form a single skin or testa; sometimes the nucleus itself becomes similarly exhausted; and sometimes nutritious matter is deposited within the tercine, or outer membrane of the nucleus. This nutritious matter, or *amnios*, in many cases is not entirely absorbed by the ovule, but remains, and constitutes the *albumen.* The embryo continues to increase, while the envelopes diminish, and ultimately forms the greater part of the seed, which, on attaining maturity, consists of the embryo, endosperm or albumen when present, and a single covering, the *episperm* or *testa,* composed of the remains of all the coats blended together. Should some of the ovules not be impregnated they soon wither, and in ovaries containing numerous ovules it sometimes happens that only one ovule is perfected, as in the Oak and Horse-Chestnut, of which the pericarps originally contain several. The mature seed has already been described, § 184.

272. Progress of the Pericarp or Fruit.—While the ovules gradually enlarge, the pericarp acquires a corresponding development, becoming more and more lea-

thery, woody, cartilaginous, or membranous, and changing from green to brown or white. In many cases the pericarp increases in a much greater ratio than the seeds, becomes succulent, acquires various bright colours, and then constitutes what is popularly termed a fruit. The rapid development of the fruit draws the sap with increased rapidity towards the branches on which it is situated, so as to cause a speedy exhaustion of the nutritious materials deposited in the stem. Hence the thinning of the fruit, by increasing the supply afforded to that left, ensures a greater development in the individuals. Some plants ripen their fruit in a few days after flowering; most of the grasses take from fifteen days to a month; many, as the Rasp and Strawberry, take about two months; the Lime and Bird-cherry, three; the Horse-Chestnut and Whitethorn, four; the Apple and Pear, five; the Beech and Walnut, six; the Olive, seven; the Colchicum, eight or nine; most Pines, ten or eleven; but some of them more than a year; and some Oaks require eighteen months. The progress of development of the fruit is much accelerated by increase of temperature. The removal of a ring of bark from the branches or stems has a similar effect, by preventing the elaborated juices from descending towards the root.

273. Action of Fruits upon the Atmosphere.—According to M. Th. de Saussure, fruits, while green, act much in the same manner as leaves, differing only in the intensity of their action. In the night they absorb the oxygen of their atmosphere, and replace it with carbonic acid, which they partially absorb again. If exposed to the sun, they disengage, entirely or partially, the oxygen which they inspired at night, and preserve no trace of carbonic acid in their own atmosphere. Many fruits, on being detached from the plant, thus add oxygen to air which contains no carbonic acid. When their vegetation is very feeble, or extremely languid, they vitiate the air

under all circumstances, but less in the sun than in the shade. Green fruits detached from a plant, and exposed successively to the action of the sun and of darkness, change the air little or not at all, either in purity or volume. In their natural state they decompose, either entirely or in part, not only the carbonic acid they have produced during the night, but also such quantity as may be artificially added to their atmosphere.

274. Chemical Changes in the Fruit.—If we examine the changes which the fleshy parts of fruits undergo in ripening, we first remark that their fibrous or cellular tissue is merely lignine; in most cases lighter and less dense than common lignine, but in the stony parts of fruits denser and heavier. The fluid in succulent pericarps consists of sap lying in the intercellular passages, and the matter contained in the cellules. It contains, besides a great quantity of water, sugar, gum, malic acid, malate of lime, colouring matter, a vegeto-animal substance, and an aromatic secretion peculiar to each fruit, besides several other substances in particular cases. On comparing ripe with unripe fruits, it is found that a large proportion of water has disappeared. This diminution appears to depend partly upon the fruit's absorbing less water as it approaches maturity, and partly upon the combination of a portion of the water it has received with its tissue. Sugar, on the contrary, continually increases as the fruit advances. It is sometimes in a concrete state, as in the Grape and Fig; sometimes liquid; and seems to be formed at the expense of other matters, which are proportionally diminished, gum, jelly, and fecula being very easily convertible into sugar. The other matters increase in some fruits, and diminish in others. In general, it may be stated, that the solid part of succulent fruits consists of lignine, and their fluid parts of water mixed with gum, malic acid, malate of

lime, colouring matter, and vegeto-animal matter, together with an aromatic substance peculiar to each species.

275. Composition of Ripe Seeds.—In the progress of development of the seed, the foramen first closes, the embryo makes its appearance in the form of an opaque speck near the summit of the nucleus, gradually projects into the cavity of the ovule, and absorbs the fluid with which it is surrounded, until, when ripe, no water remains in an unfixed state. During its solidification, it exchanges its saccharine matter for the amylaceous, oleaginous, resinous, and other secretions peculiar to it. There is also deposited among its tissue a quantity of earthy matter and of carbon, which gives it a variable degree of hardness, and it is then heavier than water. Complete maturity is not necessary to enable seeds to germinate, as may be seen in corn, which in wet seasons often germinates on the stems; but it seems essential to their preservation for a length of time.

276. Dissemination. — The manner in which the seeds are dispersed varies according to the nature of the plant, and its peculiar conditions. Sometimes, they fall immediately around the parent plant, and spring up, if numerous, to the exclusion of other plants. Many seeds and pericarps are furnished with appendages, by means of which they are transported to a distance by the winds. Of this kind are the fruits of the ash and sycamore, which have wing-like membranes; of the valerians, which have the calyx developed into filaments; and of the thistles, hawkweeds, and other Compositæ, which are surmounted by a pappus. Fleshy fruits fall directly to the ground, where they rot, unless eaten or removed by animals. The seeds of many of them, however, are encased in a hard envelope, which resists the action of moisture, and protects them from the influence of the putrid mass with which they are surrounded. Such fruits

are often eaten by animals, which digest the pulp only, the seed being passed by them. Seeds enclosed in capsules are usually dispersed by the wind, which shakes out a few at intervals, but sometimes the valves open with a jerk and scatter the seeds to a distance. "The various modes," says Sir J. E. Smith, "by which seeds are dispersed cannot fail to strike an observing mind with admiration. Who has not listened in a calm and sunny day to the crackling of furze bushes, caused by the explosion of their little elastic pods; nor watched the down of innumerable seeds floating on the summer breeze, till they are overtaken by a shower, which moistening their wings stops their farther flight, and at the same time accomplishes its final purpose by immediately promoting the germination of each seed in the moist earth? How little are children aware, as they blow away the seeds of dandelion, or stick burs in sport upon each other's clothes, that they are fulfilling one of the great ends of nature! Sometimes the *Calyx (Involucrum)* beset with hooks, forms the bur, as in *Arctium Lappa;* sometimes hooks encompass the fruit itself, as in *Xanthium*, and some species of *Galium*, particularly *G. Aparine*. Plants thus furnished are observed by Linnæus to thrive best in a rank, manured soil, with which, by being conveyed to the dens of wild animals, they are most likely to meet. The awns of grasses answer the same end. Pulpy fruits serve quadrupeds and birds as food, while their seeds, often small, hard, and indigestible, pass uninjured through the intestines, and are deposited far from their original place of growth, in a condition peculiarly fit for vegetation. Even such seeds as are themselves eaten, like the various sorts of nuts, are hoarded up in the ground, and occasionally forgotten, or carried to a distance, and in part only devoured. Even the ocean itself serves to waft the larger kinds from their native soil to far-distant shores."

277. Preservation of Seeds and Fruits.—It appears that the length of time during which seeds can preserve their vegetative powers, depends in a great measure upon the degree of protection afforded them by their integuments ; seeds that have a very thick or hard covering, generally keep much longer than those in which it is soft or membranous. It does not, however, appear that this circumstance alone is that which determines the durability of vitality in seeds, as some not firmly covered, such as those of the *Gramineæ* and *Cruciferæ*, have been known to retain the power of germinating for a long series of years. Seeds of Indian Corn have grown after thirty years, Rye after forty, the Sensitive Plant after sixty, and Kidney Beans a hundred years. On turning up ground which has not from time immemorial been under cultivation, many plants are frequently found to spring up, some of them of species different from those growing in the neighbourhood. From observations made on such occasions, and others of a like nature, it is inferred that a uniform temperature, moderate dryness, and exclusion of light, are the conditions most favourable to the preservation of seeds. Various expedients have been tried and suggested for preserving seeds during long voyages, such as putting them into bottles or tin-cases, surrounding them with wax or tallow, or burying them in dry clay ; but without much success, for most of the seeds of very remote countries seldom survive a protracted voyage, in the course of which they are subject to great alternations of temperature. The decomposition of fleshy fruits may be prevented for months, by putting them in vessels hermetically sealed, from which the air has previously been expelled.

278. Growth and Reproduction of Flowerless Plants.—In such flowerless plants as resemble in some degree those of the higher classes, we may suppose that the function of assimilation is performed in the same

manner as in them. In such other species as seem to be destitute of the varied organs described, the changes subservient to increase in size must take place in the cellular tissue, although in what manner is not apparent. But all these plants differ in being destitute of true seeds, containing reproductive germs, which in becoming developed divide into a descending and an ascending axis. Their sporules, however, are lodged in parts which may be considered as analogous in function to carpels, although they may have no structural resemblance. It is certain that the sporules of Ferns and Mosses act like the seeds of other plants in reproducing individuals of their kind; but they are mere homogeneous masses of matter, and sprout from any point of their surface; that portion which is exposed to the light shooting out into a stem, and that which is in darkness forming a root. But of the peculiarities of the lower tribes, as the Fungi, Lichens, and Algæ, physiologists profess an almost entire ignorance, with which, for the present, we must rest contented.

Recapitulation.

255. What is meant by Reproduction? By what two modes are plants naturally propagated? What are latent buds? Are plants produced by buds or bulbils in all respects similar to the individuals from which they are derived?—256. How are buds produced? Is a branch emanating from a bud a distinct individual? What is the object of grafting? What other modes of division are there?—257. What is meant by Reproduction properly so called? What organs are subservient to it? Define the seed. Is it a continuation of the individual, or a new individual? What are the periods of reproduction?—258. At what age do plants flower? In what state are flowers when first distinguishable?—259. What circumstances act as stimuli to flowering?—260. Do plants differ in the period of the year at which they flower? Do individuals

of the same species differ in the period of flowering? What advantage of this circumstance is taken by cultivators? How have fruit-trees alternate seasons of productiveness and sterility?—261. What is meant by Flora's Clocks?—262. What are the functions of the perianth?—263. How is fecundation accomplished? Mention some proofs of the existence of sexes in plants. What happens in the case of the Date Palm? How are hybrids produced?—264. Who first brought the existence of sexes into general notice? What exceptions occur to the action of the pollen? May the pollen be transmitted to a great distance?—265. How is the pollen formed? —266. How is the pollen protected from moisture? What contrivances are employed for this purpose in aquatic plants? —267. What happens when the pollen is matured? How is the stigma adapted for receiving the pollen? How is it dispersed? Is rain favourable to fertilization?—268. When the pollen adheres to the stigma, what results?—269. What happens during the period of maturation?—270. Give an account of the development of the ovules until the period of the action of the pollen. What is meant of orthotropous, campulitropous, and anatropous ovules?—271. Describe the progress of the seed after impregnation—272. Give an account of the growth of the pericarp. How does thinning the fruit tend to enlarge it? Do plants vary much with regard to the time occupied in maturing their fruit? What circumstances accelerate maturation?—273. What effect have fruits upon the atmosphere? —274. What chemical changes take place in the fruit?—275. What is the composition of ripe seeds?—276. How are seeds dispersed?—277. Do seeds long retain their vitality? What circumstances are favourable to their preservation?—278. Are the functions of growth and reproduction performed in flowerless plants in the same manner as in others? In what respect are sporules different from seeds?

CHAPTER XXIV.

DIRECTION OF THE ORGANS OF PLANTS.

279. General Observations.—We know, as a general fact, that terrestrial bodies tending towards a central point become aggregated so as to produce an integral mass of matter forming the globe of the earth, and to this general fact we give the name of gravitation; but of the causes and essential nature of gravitation we are ignorant. In like manner, we observe that a plant in germinating shoots a stem upwards into the air, and a root downwards into the ground, and we can perceive the advantages resulting to it from so doing; but we have not discovered the causes by which it is impelled to perform these actions. The phenomena are so common and so obvious that they scarcely attract notice or excite reflection; yet philosophers have failed to account for them. Although it is strictly true that stems ascend and roots descend, yet their direction is seldom vertical in the advanced state of the plant. Roots after proceeding downwards, branch out, and run obliquely into the soil, often spreading to a great extent, even farther than the branches; stems are often inclined, sometimes even prostrate; and branches incline in all directions, sometimes even curving downwards.

280. Effects of Gravitation.—Various hypotheses have been adduced to account for the direction of the stems and roots; but philosophers have usually, as in other puzzling cases, referred it to the action of the vital principle. It has been supposed by some that gravity is the cause of this phenomenon. Mr Knight affixed some French beans to the circumference of two wheels, one

horizontal, the other vertical, and both kept in constant motion. The radicles of the seed on the vertical wheel extended outwards, the plumules inwards. The seeds on the horizontal wheel sent their radicles downwards, and their plumules upwards; but the radicles inclined outwards, and the plumules inwards, and the more so in proportion to the velocity of the wheel. These modifications of direction were obviously produced by the centrifugal force obviating the effects of gravity; but still this does not account for the natural direction of the radicle. Some had supposed that there is an affinity between the root and moisture or darkness. Dutrochet filled with earth a box, in the bottom of which holes were bored. In those holes he placed French Beans, and suspended the box in the air, at the height of about eighteen feet. The seeds thus received from beneath the influence of the atmosphere and light, and the moist earth was placed above them. Were the cause of the direction of the root its predilection for moist earth, the radicle would ascend; but this was not the case, for the roots shot downwards into the air and soon withered, while the plumules ascended into the soil. It was thus found that there was no affinity between the radicle and the seat of moisture sufficient to counteract its natural downward tendency; and it was also inferred that no more positive affinity existed between the stems and the atmosphere.

281. Germination of the Mistletoe. — Parasitic plants, or such as strike their roots into the stems of other plants, seem to be exempt from this general tendency. Thus, the seed of the mistletoe, which are enveloped in a slimy substance, will germinate in any direction, upwards, downwards, or laterally. When it happens to fix itself to the upper part of a branch, its radicle will be directed downwards; but when it is placed on the lower part, the radicle directs itself upwards. M. Dutrochet made it germinate on a cannon ball, when he

found that it always directed the radicle toward the centre. Hence it is obvious that the tendency of the root of this plant is not towards a medium suited to afford nourishment to the young plant, but that it obeys the attraction of the body on which the seed is fixed, of whatever nature it may be. It is the same with parasitical fungi, and other agamic plants, which do not grow on the ground, but obey the attraction of the bodies to which they adhere.

282. Effects of Light.—The radicle of the mistletoe presents another unvarying tendency, that of avoiding light. If seeds of this plant are made to germinate on the inner surface of the pane of a window, all the radicles will be seen turning from the light, and projecting toward the interior of the apartment. If placed on the outside of the glass, their radicles will apply themselves to it, as if tending toward the shade. But the stem of this plant does not shew the opposite tendency of directing itself towards the light, for its branches are developed indifferently in all directions. Yet the stems of plants in general evidently seek the light, as is shewn by making them grow in a room, in which light is admitted by a single aperture, in which case they invariably direct themselves to it. This has been supposed to be owing to the greater decomposition of carbonic acid on the side next the light, and a greater deposition of carbon on that side, in consequence of which it acquires a greater rigidity, and the other side having more freedom of development, the stem bends. M. Dutrochet infers from this and other phenomena of a like nature, that light is a principal cause of the direction of the organs of plants; but that those parts only which are green are attracted toward it, while those which are colourless have a contrary tendency, insomuch, that colourless stems are known to assume the direction of roots.

283. Direction of the Leaves and Flowers.—The surface of the leaf which is next to the upper part of the plant is always directed toward the sky, and this disposition or tendency is so strong, that, if the position of the leaf be inverted, the petiole will become twisted, so that the leaf will recover its natural position. The upper surface of leaves, in general, is more deeply coloured than the lower; and, as in the case of the stem seeking the light because green, and the root receding from it because pale, it has been said that the upper surface seeks the light, not because it is the upper surface, but because it is of a deeper green. This law is so constant, that, if the surface of a leaf which is naturally inferior is more deeply coloured than the other, the petiole will become twisted, so as to turn it upwards. The same circumstance is observed in the petals, of which the upper surface is generally more highly coloured. But still it is supposed that the direction of the leaves is not mechanically caused by an external agent, but is due to a spontaneous motion, put in action by the influence of external agency. M. Dutrochet took a leaf, and cutting off its petiole, substituted it by a hair, and sinking it by a weight in a vessel of water, exposed it to the light, the lower surface of the leaf being turned toward the window. No alteration in its position took place, although leaves immersed in water under similar circumstances, but with their petioles and stem uninjured, turned towards the light. In many instances the direction of the flowers is dependent upon mechanical causes. Thus, when the peduncles are slender and feeble, the flowers necessarily droop, as in many Grasses, the Common Bell-flower, and Hyacinths. But the ultimate cause of the directions assumed by flowers is probably the protection of the sexual organs during the process of fertilization.

Recapitulation.

279. What is the general direction of the stem? Do roots always descend perpendicularly?—280. What is the cause of this direction? What happened in Mr Knight's experiment when beans were made to germinate on the circumference of two wheels in motion? Has the root a special predilection for moisture? When Dutrochet caused seeds to germinate in holes in the bottom of a suspended box, what happened?—281. State the peculiarity of the Mistletoe as to germination. Is it the same with any other plants?—282. State the circumstances shewing that the radicle of the Mistletoe tends to avoid the light. How is it shewn that stems seek the light? How has the curvature of a stem toward the light been accounted for? What is M. Dutrochet's general inference on this subject?—283. If a leaf be inverted, what happens? What side of a leaf is most green? Why is the upper side directed to the light? Is the direction then entirely caused by light? What happened when a leaf was sunk in water with a hair substituted for its petiole? Why do many flowers droop? What is the probable reason for the directions of flowers?

CHAPTER XXV.

METAMORPHOSIS OF ORGANS.

284. Regular Metamorphosis.—It has been assumed, in consequence of an extended comparison of plants with reference to the form, arrangement, and mutual transition of their organs, that all the parts appended to the ascending axis are modifications of a single organ, and may be considered as leaves adapted to special purposes. The organs of plants are disposed, so as to constitute several series or verticils of leaves; and it is found, that

in many cases these verticils pass into, or are substituted by each other.

285. Leaves, Stipules, and Bracteas.—The *Leaves*, which have already been pretty fully described, may be assumed as the fundamental organs. Appended to, or connected with them, are the *Stipules*. These organs are not present in all plants. Sometimes they are membranous appendages, destitute of vessels, or having a vascular fasciculus running up their centre. Frequently, as in Roses, and the *Leguminosæ*, they are in pairs, appended to the base of the leaf-stalk, and have a structure similar to that of the divisions of the leaf, although they may differ in form. Sometimes they have the appearance of distinct leaves. They may therefore be considered as rudimentary leaves, or as parts of the leaf. The *Bracteas* are organs intermediate between the leaves and the sepals. In very many plants the leaves, larger and more divided at the base of the axis of vegetation, become gradually smaller and more simple as they ascend on it, and at length, changing their colour and assuming a more membranous structure, appear as bracteas. Here no real distinction can be made between the leaves and the bracteas. In some Roses the bracteas are exactly similar to the leaves, while in others they are expanded peduncles with enlarged stipules. In the garden Tulip, a bractea is often seen at some distance from the flower, which, in texture and colour, partakes of the nature both of the leaf and the sepal. It has been said that bracteæ differ from leaves, in having no buds in their axillæ; but this is not always the case; for in viviparous plants, such as *Polygonum viviparum*, the flowers themselves are converted into buds in the axils of the bracteæ; *Bellis perennis* sometimes bears buds in the axils of the involucral leaflets; and, in the bracteas of Roses, there is always a bud.

286. Calyx and Corolla.—The *Sepals*, as every one

must have observed, very often resemble the leaves in structure and colour, sometimes more or less in form. In Roses, one of the sepals is obviously formed like a leaf, and the rest more or less so. The sepals often differ very little from the bracteæ, and in many plants these organs are perfectly identical. It has been objected to this assimilation, that the sepals are always verticillate, or come off at the same level, and that they seldom have buds in their axillæ; but, in order that organs should be considered as modifications of each other, it is not necessary that they should agree in all their characters. Leaves themselves are frequently verticillate in various degrees, and although they should usually be spirally disposed, they might very naturally be supposed to become verticillate when proceeding from the abrupt termination of the axis or branches. In some cases also, as in Double Tulips, the outer leaves or sepals lose their verticillate arrangement; and in double Lilies, all the parts of the flower are disposed alternately upon an elongated axis. The sepals then are leaves reduced to a particular state.

287. Corolla and Stamens.—The corolla is composed of a series of leaves, alternating with those of the calyx, and not always distinguishable from them. In many plants the sepals and petals are alike in colour, texture, and odour; and when the perianth is single, the sepals and petals seem to be combined. The stamens, when in a single row, alternate with the petals; or, if opposite to them, may be considered as belonging to a second or inner row. The expansions of the filaments sometimes form petaloid bodies, as in the cup of Narcissus, which, from analogy, is considered as formed of the three outer stamens expanded and united. In the White Water-Lily, the petals gradually diminish in size toward the axis, their margins become altered and assume a yellow colour, and the transition proceeds until we come to the regularly

formed stamens. A similar transition is observed in Double Roses, Anemonies, Ranunculuses, Cherries, and Almonds.

288. THE CARPELS.—In its most simple state, the Carpel bears the greatest analogy to a leaf, as is seen in the pod of the pea, which resembles a leaf folded upon itself. The same structure is seen in many fruits, of which the carpels are arranged in a verticil, and from the various modifications thus produced are derived the varieties of form, and internal division of the ovarium, which have already been described, § 180, 181. Sometimes the pistil reverts to the state of a green leaf, folded upon itself, as in the double Cherry. Frequently also it reverts to the state of petals, as in double Narcissi, Wall-flowers, Ranunculuses, and .Saxifrages. It is remarkable, however, that the pistil seldom reverts to the form of the stamen, and that transitions between the stamens and pistils are very rarely met with.

From what has been said above, it appears that all the organs of Flowering Plants are similar in their general plan, graduate into each other, and may be considered as leaves modified for special purposes. The subject is what some have named *Morphology*, and refers to the natural or normal condition of the organs.

289. IRREGULAR METAMORPHOSIS.—Owing to various circumstances, especially superabundant nourishment, change of soil and climate, and the alteration of the natural condition of plants, they undergo many changes in all their organs. It is probable that every plant has a particular range of distribution, in which, being subjected to limited atmospherical influences, it remains unchanged; but that, when its conditions are materially altered, its form and functions are liable to be modified. In the wild or natural state changes of this kind are rare, while in our gardens and hot-houses they are continually taking

place. Of the essential causes of these changes, and the precise manner in which they are effected, it appears that nothing is known with certainty.

290. Changes of Roots and Tubers.—The roots of plants undergo numberless changes. Thus, the wild carrot has a slender tapering fleshy root of a yellowish-white colour; in sandy soil denser, more tinged with yellow, and having an aromatic flavour; in rich soil, more succulent, whiter, and sweetish. Under cultivation, it increases, becomes much more fleshy, and assumes a deep orange or red colour. The Parsnip varies from fusiform to conical; the Turnip from globular to depressed, turbinate, and fusiform, the epidermis being white, yellow, purple, or partially green. The Potato assumes numberless shapes, being orbicular, oblong, flattened, or curved, and various colours, as white, yellow, red, purple, or variegated; even its interior becoming sometimes purple or blackish.

291. The Stem and Leaves.—Changes of the stem are less frequent. In alpine situations the stem becomes short, and in low and humid situations elongated; in open pastures firm and coloured, in woods more tender and green. By domestication tall stems are rendered short, and short stems lengthened. The stem of the Wild Cabbage is rather firm and slender, but in a cultivated variety it has become fleshy and fusiform, and in another forms a fleshy tumour above the ground. The changes which leaves undergo are numberless. In some varieties of the Cabbage and Lettuce, for example, they enlarge, become more succulent, and curve inwards, forming what gardeners call a heart. In other varieties, the parenchyma increases more than the veins, and they become puckered; and again, the margins enlarge more than the disk, when they become curled. Simple leaves assume various marginal alterations, or even become compound; and compound leaves are sometimes rendered simple, or lose

some of their parts, or acquire additional parts. The colours of leaves also undergo many changes.

292. CHANGES OF FLOWERS.—Changes in the floral organs are extremely common. The petals are increased in number, stamens are converted into petals, the colours of the parts are altered, and their odours modified. The sepals of the Tulip, which are six, are multiplied indefinitely, and assume numberless tints and patterns. Roses, Anemonies, and Ranunculuses, which in the natural state have five petals, acquire an indefinite number. When the petals are increased by an additional verticil or two, the flower is said to be *double;* but when the increase is so great as to destroy the sexual organs, it is said to be *full.* "With regard to colour," as Professor Lindley observes, "its infinite changes and metamorphoses in almost every cultivated flower can be compared to nothing but the alterations caused in the plumage of birds, or the hairs of animals by domestication. No cause has ever been assigned to these phenomena, nor has any attempt been made to determine the cause in plants. We are, however, in possession of the knowledge of some of the laws under which change of colour is effected. A blue flower will change to white or red, but not to bright yellow; a bright yellow flower will become white or red, but never blue. Thus, the hyacinth, of which the primitive colour is blue, produces abundance of white and red varieties, but nothing that can be compared to bright yellow, the yellow hyacinths, as they are called, being a sort of pale yellow ochre verging to green. Again, the ranunculus, which is originally of an intense yellow, sports into scarlet, red, purple, and almost any colour but blue. White flowers, which have a tendency to produce red, will never sport to blue, although they will to yellow; the Roses, for example, and Crysanthemums."

293. CHANGES IN THE FRUIT.—These are very com-

mon and obvious. The Crab Apple, a small, globular, acid fruit, has, by cultivation, been converted into numberless varieties, differing in size, colour, flavour, and smell. The Sloe, in like manner, has produced the different kinds of plum. The varieties of the Bean and the Pea, and in short of almost all the plants cultivated for their fruits or seeds, are endless. In herbaceous plants, these varieties may be propagated by the seeds, but in trees only by subdivision, that is by grafting, by slips, suckers, or layers.

RECAPITULATION.

284. Do the organs of plants graduate into each other?—285. Have all plants stipules? What appearances do the stipules present? Why may they be considered as rudimentary leaves, or as parts of the leaf? How do leaves graduate into bracteas? What takes place in Roses and Tulips? Have bracteæ axillar buds?—286. Do sepals ever resemble leaves or bracteas? How do they differ from leaves as to arrangement? Are leaves ever verticillate? Are sepals always so?—287. Of what is the corolla composed? Are the sepals and petals ever similar on the same plants? Do the stamens ever assume the appearance of petals? Mention an instance of the gradation of petals into stamens.—288. How is a carpel analogous to a leaf? Mention an instance of the pistil becoming a leaf. In what plants does the pistil revert to the state of petals? What is Morphology?—289. What is meant by Irregular Metamorphosis? How are changes produced in plants?—290. Mention some instances of changes in the root.—291. What changes take place in the stem? Are the leaves very liable to change?—What is called a heart? How are curled leaves produced?—292. What changes take place in flowers? What are Double and Full flowers? Do all colours change into each other?—293. From what plants are the cultivated apples and plums derived?

CHAPTER XXVI.

REMARKS ON THE GEOGRAPHICAL DISTRIBUTION OF PLANTS.

294. General Remarks. — Botanical Geography, which includes the distribution of plants over the globe, the relative number of families, genera, and species, in different districts, the influence of heat, altitude of situation, and soil, the means of dispersion and limitation, together with various subordinate subjects, cannot be here spoken of in full, because a knowledge of the specific forms of plants, and their arrangement into groups, is necessary to him who would enter upon its consideration. But some observations on this important subject may here be made with advantage to the student. If we examine our own country with reference to its vegetation, we find, that many of the plants which occur on the sea-shore are different from those met with in the interior, and that the summits of mountains exceeding 3000 feet in height have a vegetation unlike that of the plains and valleys. Were we to extend our view to other countries, we should find, that although most of the plants of Britain occur in France, while those of the latter country reappear in Spain, yet that many species are peculiar to each of these regions; and that countries very distant from each other, as Otaheite and Spitzbergen, have few or no plants in common.

295. Stations of Plants.—The situations in which plants naturally thrive best, considered as to elevation, the nature of the soil, proximity to the sea or to the

snow-line, and other circumstances of a like nature, are termed *Stations.* Of these the following are the most definite :—

1. *The Sea.* Many plants live immersed in salt water, or float on its surface. Of this kind are most of those forming the family of *Algæ.* They are accordingly termed *Marine Plants.*

2. *The Sea-shore.* Others reside on the borders of the sea, and thrive only when exposed to the influence of the spray and sea-breezes. Of this kind are the *Salicorniæ, Glaux maritima,* and *Arenaria peploides.* It is very remarkable, that several plants which grow near the sea occur on the summits of high mountains ; as *Statice Armeria, Plantago maritima,* and *Rhodiola rosea.* Plants whose station is the sea-shore are named *Maritime.*

3. *Fresh water.* Some plants live in fresh water, entirely submersed, as *Confervæ ;* floating loose on the surface, as *Stratiotes ;* rooted in the mud, with the leaves and flowers floating, as *Nymphæa ;* or similarly rooted, but with these organs rising above the surface, as *Alisma Plantago.* Such plants are *Aquatic.* They are also named *Lacustrine* when growing in lakes, and *Fluviatile* when in rivers.

4. *Marshes.* Hollows or low grounds partially covered with water, or entirely covered to a small depth, or covered in one season and dry at another, as well as the wet margins of lakes and rivers, ditches, and wet meadows, produce certain plants, as *Menyanthes trifoliata, Caltha palustris, Galium uliginosum.* Such are termed *Palustrine.*

5. *Pastures. Meadows,* or moist grassy places ; and *Pastures,* or dry grounds covered with grass. *Cardamine pratensis, Poa pratensis, Senecio Jacobæa. Meadow* and *Pasture Plants. Pratensine.*

6. *Cultivated Lands.* Together with pasture plants, this kind of ground produces species introduced by the

agency of man. *Stellaria media, Spergula arvensis, Agrostemma Githago. Arvensine.*

7. *Rocks.* Many cryptogamic plants abound on rocks, and a few others prefer them. Old buildings and walls rank with rocks in this respect. *Saxifraga hypnoides, Cheiranthus Cheiri. Rupestrine, Murine.*

8. *Sands, Sandy or Gravelly Soil.* This kind of station ought to refer to the interior exclusively, but is not definite. *Arenaria serpyllifolia. Arenaceous Plants.*

9. *Rubbish.* Places in the vicinity of dwellings nourish plants, such as the Nettle, which seem to follow man. *Ruderal.*

10. *Woods.* Forests and woods of tall trees. The plants growing in this kind of station are the trees themselves, and the herbaceous plants which thrive in their shade. *Sylvan.*

11. *Copses.* Thickets, hedges, and bushy places. Shrubs and herbaceous plants. *Dumose.*

12. *Mountains.* Hills and mountains produce numerous plants not found in valleys or plains. This head includes upland pastures, mountainous situations, and alpine stations, the latter being those near the line of perpetual snow. *Colline, Montose, Alpine.*

13. *Caves.* Dark places under ground, such as caves, mines, wells, and the like, produce some peculiar plants, which may be called *Subterranean.*

14. *Plants.* Many plants grow on others, whether living or dead, without deriving nourishment from them, and are named *Epiphyte;* while others, adhering to the surface of plants, extract nourishment from them, and are said to be *Parasitic.*

296. Habitations of Plants.—The particular kind of situation in which a plant occurs, for example, the sea-shore, differs from what is technically called its *Habitation.* This latter term is applied to the range of

growth of a species, or the extent of the earth's surface, on which it is found in a natural state. It is a remarkable circumstance, that most plants are restricted, not only in longitude, which they might readily be supposed to be from the effects of temperature alone, but also in latitude. Plants of particular species, therefore, do not form transverse belts on the earth's surface, but are distributed in irregular patches. Perhaps no plants are of general distribution; but some have an extensive range, and are found in both hemispheres. But the greater number are restricted within moderate, and many within narrow limits. It is thus probable that plants have not emanated from original individuals placed in a central district, or in several centres of vegetation, but have been derived from individuals placed originally in particular spots, from which their offspring have radiated until their migrations have been stopped by seas, deserts, mountain-ridges, and similar obstacles.

297. CIRCUMSTANCES FACILITATING MIGRATION.—The dispersion of plants appears to take place chiefly by means of the atmosphere. As has already been stated, § 276, the seeds of many plants are so small and light that they are easily transported by the winds; while others are furnished with wings or crowns, which render them lighter by increasing their surface, or they are surmounted by tufts, the filaments of which, on separating, serve as levers, to enable them to issue from the pericarp or involucre, and afterwards support them in the air. The minute sporules of cryptogamic plants especially, appear capable of being transported to considerable distances in this manner. Rivers are also a probable means of dispersing seeds, and are known occasionally to carry entire plants from the mountainous regions to the plains. The sea occasionally serves the same purpose in warm climates, but its effects have been greatly overrated. Seeds frequently become entangled in the wool and hair

of animals, and may be carried to some distance, while others pass through their alimentary canal uninjured, and may spring up in places remote from that of the parent plant. Man, however, has done more for the dispersion of plants than all the other animals. Some are accidentally transported by him wherever he extends his migrations, and many have been purposely carried by him to all parts of the globe.

298. Obstacles to Migration.—The ocean presents an obstacle to the migration of plants proportionate to its extent; for, as salt water is found to destroy the vitality of seeds long subjected to its influence, there is less chance of an interchange of species between lands situated at great distances from each other than between those which are near. Regions covered with arid sand, such as occur on the African Continent, may also be supposed to present effectual barriers to the extension of vegetation; and thus the plants of the western are different from those of the northern and eastern parts of that continent. Elevated mountain-ridges, especially when they rise into the region of perennial snow, have a similar, but less remarkable effect; for, although the cold of their summits may form a sufficient obstacle, they are intersected by ravines and transverse valleys, by which migration may take place. Other circumstances might be mentioned, as forming obstacles to the dispersion of plants; but the circumstances which have the greatest influence upon it are light, heat, moisture, and the nature of the soil.

299. Influence of Soil.—The chemical nature of the materials of which the soil is composed, appears to have very little influence upon the kind of vegetation which it produces. The same species are found to grow in soil of which carbonate of lime is a principal ingredient, and in that composed chiefly of alumina or magnesian earth; and maritime plants grow in calcareous as

well as in siliceous sand; while alpine species are found on granitic as well as on schistose summits. It is therefore probable, that the degree of disintegration of the materials of which soils are composed, and their capability of retaining moisture, are the circumstances on which their adaptation for particular plants chiefly depends. The degree in which water is retained in the soil is generally proportionate to the quantity of alumina in it; and those soils which contain siliceous matter in a state of comminution, most readily give out their moisture.

300. Influence of Moisture.—The different stations of plants above enumerated are differently supplied with moisture; and different species of plants are differently constituted in this respect. But, beyond a few superficial generalizations, it does not appear that much is known on this subject. The greater the supply of moisture, combined with a proportional heat, the greater is the development of vegetation; and while the arid wastes of Africa scarcely produce any plants, the borders of springs or pools which occur on them are furnished with palms and other plants, which flourish luxuriantly. While the great plains of South America are during the seasons of drought converted into regions of sterility, no sooner have the periodical rains fallen than they present an ocean of verdure.

301. Influence of Heat.—As we proceed from the equator towards the pole, we find that the vegetation gradually decreases in vigour; and, as we ascend from the sea-shore towards the summits of lofty mountains, we observe a repetition of the same circumstance; until at last, having come to the limits of perennial snow and ice, we find a total cessation of vegetative power. Various forms of vegetation present themselves in different regions; and, in passing from the equator to the pole, we traverse a succession of regions characterized by peculiar plants, insomuch that, although two contiguous regions

may not differ very remarkably, the extremes of the series may have no plants in common. As the temperature diminishes in proportion as we ascend a mountain-chain, the vegetation presents itself in belts or zones, certain species being confined within certain limits as to height. But the zones of vegetation observed from the equator to the pole are undefined and interrupted, the species being of varied extent, both as to longitude and latitude. The mean annual temperature, differences in the same latitudes between the heat of summer and winter, and other circumstances, give rise to these irregularities, the consideration of which requires a previous knowledge of the families of vegetables, as well as of other subjects not properly belonging to those treated of in this volume. The Geographical Distribution of Plants will form a separate section in another volume, and has been alluded to here only as connected with Vegetable Physiology, a principal object in view being to lead the student gradually onward from one department to another.

RECAPITULATION.

294. What is meant by Botanical Geography?—295. Describe the different stations of plants.—296. What is meant by Habitation?—297. What circumstances facilitate Migration of plants?—298. What are the principal obstacles to the migration of plants? Has salt water an injurious effect upon seeds? How do deserts prevent the dispersion of plants? Do mountain chains present equally insurmountable barriers?—299. Has the chemical nature of the soil much influence on the distribution of plants? On what circumstances does the adaptation of soils for particular plants chiefly depend? What soils are most retentive of moisture?—300. What effect does moisture produce on the vegetation of the deserts of Africa, and the plains of South America?—301. What is observed with regard to the vegetation in proceeding from the equator to the pole, and from the sea-level to the summits of mountains?

CHAPTER XXVII.

SPECIES, VARIETIES, AND HYBRIDS.

302. General Idea of Species.—Although the idea of a *Species*, or particular kind of plant or animal, is familiar, and generally understood, it is difficult strictly to define the limits of each species, or to form a correct general idea of what is meant by the term. A Lion, a Tiger, an Elephant, a Horse, and a Man, are individuals representing so many species. The particular Lion referred to, and all the other Lions in the world, constitute the species to which we give the general name of Lion; and so of the others. But, if we examine all the Lions in the world, or as many of them as we can find, we may be induced to conceive that there may be several species of Lions; for example, the Asiatic Lion, the Barbary Lion, and the Senegal Lion. So also there may be several species of Elephant; and in fact, we know two, the Asiatic and the African. Now, if these two Elephants, which differ in characters not remarkably obvious, are yet distinct, are we to consider all such characters always indicative of distinct species? The Bull-dog, the Shepherd's Dog, and the Greyhound, differ very considerably from each other. Are they distinct species, or merely varieties of one species? It is pretty generally agreed, that individual animals which breed together, and produce a fertile progeny, are of the same species. If this opinion be correct, all the domestic dogs are merely varieties of a single species; the European Man, the Negro, the Malay, the Tartar, and the New Hollander, belong to one and the same species. It is the same among plants. If among them we define a species to be—the aggregate of indivi-

duals agreeing in all their essential characters, breeding freely together, and producing perfect seed, which gives rise to similar individuals, also breeding together—we may be correct, but our definition is vague, and not applicable in practice, for it is only in very few cases that we can determine species by it. There is nothing absolutely certain as to species, much less as to the groups into which they are disposed, as genera, families, orders, tribes, and the like. We merely agree to consider as species individual plants which closely resemble each other in the structure and form of their organs. Such species, however, often pass into each other by gradations, which render it impossible to draw a line of demarcation, and thus all species are more or less arbitrary. We know from observation, that all assumed species undergo changes from climate, cultivation, and other influences; and individuals exhibiting remarkable alterations we call collectively varieties; but variety is a still more vague idea than species.

303. VARIETIES.—If we assume that a few individual plants, precisely similar in all respects, and differing in some respects from all others, were originally created, we should call these plants and their progeny, up to the present day, a species. Or a single original plant and its offspring would be a species. From various causes, individuals that have been derived from these original individuals may differ considerably from them, and yet be of the same species. Supposing a plant to have been originally, or many individuals of its offspring to be at present, three feet high, with an erect stem, cordate downy leaves, and blue flowers, one or many individuals of the same may be much smaller, with decumbent stem, oblong hairy leaves, and white flowers, although in other more important characters they might agree, such changed individuals would form a *Variety*. While species, having the normal form and colours, are perpetuated by seed,

varieties, although often also propagated in the same manner, are liable to return to the original form, or to deviate into others; and accidental varieties, originating in cultivation, must be propagated, if it be desirable to preserve them, by grafting, or by slips, or such other means. All species have a tendency to form varieties, insomuch, that no two individuals are ever precisely alike in all respects. The general idea of a variety is thus as vague as that of a species; and the only correct idea of species would be that which should include every character or feature common to all the individuals composing it. But our idea of species is derived from the form of the organs merely. In practice, however, we contrive to distinguish species sufficiently for many useful purposes.

304. HYBRIDS.—Among wild animals, individuals of a species usually have so much aversion toward individuals of another species, that instances of sexual union are extremely rare. Among plants in the same state, although not having instincts and propensities like animals, an intermixture of species is also of very rare occurrence. This probably arises from impregnation having been effected before the pollen from another plant can reach the stigma. But, in a state of cultivation, hybridism sometimes occurs, and may readily be induced by art. It is only plants of the same genus, or, at most, of very nearly allied genera, that intermingle in this manner. Even species of the same genus, if very different in appearance, cannot be made to produce hybrids. If the anthers of a plant be removed before bursting, and the pollen of another species of the same genus be applied to its stigma, there will be produced seed, which will give rise to individuals having characters partaking of the nature of both parents. The individuals thus produced are capable of performing all the functions of their parents, but they cannot produce seed capable of giving rise to individuals similar to themselves; for sometimes

they are sterile, or become so in a few generations, or the individuals produced by them tend to return to the form of one or other of the parents, and if a hybrid individual be artificially impregnated with the pollen of one or other of the species from which it has originated, it will return to the form of that species. It is possible that some supposed species may be mere hybrids, as in the genus *Rosa* and *Rubus;* but it seems more probable that, if not species, they are rather varieties than hybrids. There are, however, various instances of hybridism, even in the wild state; but this accident or circumstance appears to have little general effect in modifying the vegetation of the globe. Although we have no certain data from which we can infer the general permanence of specific forms, yet the considerable number of plants, or parts of plants, found in the catacombs of Egypt, shew that the species to which they belong have continued unaltered for more than 3000 years.

RECAPITULATION.

302. Is it difficult to define species? What is the cause of the difficulty? What is a species of plants? Do assumed species often pass into each other?—303. What is meant by a Variety? Are varieties propagated by seed?—304. What is a Hybrid? Why are hybrids rare in the wild state? How may they be artificially produced? Will any two species of plants produce hybrids? May hybrids be perpetuated by their seeds? Are there any reasons for supposing that specific forms are permanent?

CHAPTER XXVIII.

DISEASES, DURATION, DECAY, AND DECOMPOSITION OF VEGETABLES.

305. Diseases of Plants.—Like animals, plants are subject to deviations from the healthy condition of their organization, but their diseases are less numerous, less complicated, and it may be added, less known. It will suffice here to mention some of the most common forms of disease.

1. *Blanching.*—A kind of constitutional feebleness, indicated by elongation and slenderness of the stem and branches, incapability of producing, or at least of perfecting flowers, and a general paleness of the green parts. Moisture, combined with cold, and little sunshine, may be the cause of this disease.

2. *Gangrene.*—A general languor of the system ; flaccidity of the leaves, and decomposition of them and the twigs ; probably arising from excessive cold, and subsequent rapid change to heat. The disease may be general or local.

3. *Canker.*—According to Professor Lindley, this affection "exhibits itself internally in a brown discoloration of the medulla and parts adjacent, and externally in small brown dead spots, which gradually extend on all sides, until they surround the branch and kill it. These spots are always dry and hard, never containing any fluid. It is this which is so fatal to many of the apple and pear trees of this country. Its cause and mode of cure are equally unknown. Apparently, healthy shoots will, if grafted on another stock, carry the disease with them."

4. *Carcinoma.*—As defined by the same author, this

"is a disease in which an unusual deposit of cambium takes place between the wood and bark; no wood is formed, but instead, the cambium becomes putrid, and oozes out through the bark, which thus separates from the alburnum."

5. *Spotting.*—The appearance of small black spots on the leaves and parenchymatous parts of plants, with decay of the subjacent substance.

6. *Gumming.*—A discharge of thick sap through the bark, with drying of the surrounding parts.

7. *Excrescences.*—By the puncture of insects, excrescences of various kinds are produced on the leaves and stems of plants, sometimes the calyx, germen, or other parts. The irritation caused by the egg, or by the larva, of the insect, causes a deposition of parenchymatous tissue, which assumes various forms, but does not affect the general health of the plant, or even that of the neighbouring parts. Gall-nuts are produced in this manner.

8. *Smut and Rust.*—A conversion of the seed or other part of a plant into a granular substance of a brown, black, red, or yellow colour.

9. *Ergot.*—An enlargement and elongation of the seeds of grasses, which assume a brown or blackish colour, and contain a powdery, somewhat unctuous substance, producing very deleterious effects on animals which feed on grain intermixed with it.

Many other diseases, distinguished by fanciful names, and bearing little analogy to the diseases of animals similarly named, might be mentioned. Thus, *Hypertrophy* is an enlargement of a part or organ; *Pernio,* a wound or ulcer caused by frost; *Exostosis,* a "clubbing of the roots." Besides, plants are liable to external injuries of various kinds: *Wounds, lopping, fracture, constriction* by climbing plants, *erosion* by animals, and the like.

306. Duration of Plants. — Some species of vege-

tables exist only a few days, a few weeks, or a few months, and are named annual plants. Other species which spring up in autumn, survive the winter, produce flowers in summer, perfect their seeds and die in autumn, are named Biennial. Plants of these kinds produce seeds only once in their lives, and so are said to be *Monocarpean.* Others which last several years, produce fruit more than once, and thus obtain the title of *Polycarpean.* Of these some last only a few years, while others extend their duration over a long series of years, and many endure for centuries, nay even thousands of years. These long-living plants are all ligneous, and belong to both divisions of the Embryonate series.

307. Longevity of Trees.—The age of dicotyledonous trees may be satisfactorily ascertained by counting the number of woody layers in a transverse section. But an approximation may be made even in a living tree. The rate at which trees of a particular species increase in diameter within known intervals may be determined by measuring the radius, or the diameter, of sections of different individuals, and thus finding the average annual increase. The diameter of a growing tree being ascertained, its age may be guessed at by referring to the known rate of increase of the species. Thus, M. De Candolle having ascertained that three yew trees, which were felled, had grown at the rate of a twelfth of an inch in diameter annually for a hundred and fifty years, and that one of them had increased somewhat less rapidly during the next century, applied the rate of growth thus obtained to some English yews described by Evelyn and Pennant, one of which, mentioned by the former as growing at Braburn in Kent, in 1666, was fifty-eight feet nine inches in circumference, or 2820 lines in diameter, and therefore as many years old. But this method is liable to objections, inasmuch as trees do not increase uniformly in diameter, some layers being much

thicker than others, and trees grow more rapidly in their first years than afterwards. Adanson found, that some Baobab trees in Senegal had increased two feet in diameter in two centuries, so that individuals thirty feet in diameter would be 3000 years old. But, by ascertaining the height and diameter of young trees of various ages, he came to the conclusion, that a tree twenty feet in diameter would be 2800 years old, and one thirty feet, 5150 years. But, if these and other methods of estimating the age of trees are not entirely to be depended upon, there can be little doubt that many individuals now living are some thousands of years old, and that some may even be coeval with the human race.

308. Fall of the Leaf.—Plants having, for a period peculiar to each species, lived, vegetated, and fructified, begin to decay. Even yearly, in the perennial species, there is a decay of some of the organs. In some, the whole plant dies down to the roots; in others, the leaves only fall off. The fall of the leaf in autumn has been variously accounted for. It is observed, that in general, the trees whose leaves are earliest expanded are those which lose them first, as is the case with the Lime, Birch, and Plane. The Ash is an exception, its leaves being very late in expanding, and early in falling. Petiolate leaves, and especially those which are articulated upon the stem, are sooner detached than those which are sessile or amplexicaul. In herbaceous plants, the leaves generally decay along with the stem, without falling. Although the fall of the leaves usually takes place at the approach of winter, cold is not the cause of the phenomenon, but rather the interruption to the course of the sap, when vegetation ceases, the vessels of the leaf becoming dried up.

309. Decay of Plants.—On this subject Dr Thomson of Glasgow has the following remarks:—"As long as a plant continues to vegetate, we say it lives; when it

ceases to vegetate, we conclude that it is dead. The life of vegetables, however, is not so intimately connected with the phenomena of vegetation, that they cannot be separated. Many seeds may be kept for years without giving any symptom of vegetation ; yet, if they vegetate when put into the earth, we say that they possess life ; and, if we would speak accurately, we must say also that they possessed life even before they were put into the earth : for it would be absurd to suppose that the seed obtained life merely by being put into the earth. In like manner, many plants decay, and give no symptoms of vegetation during winter ; yet, if they vegetate when the mild temperature of spring affects them, we consider them as having lived all winter. The life of plants then, and the phenomena of vegetation, are not precisely the same thing ; for the one may be separated from the other, and we can even suppose the one to exist without the other. Nay, what is more, we can in many cases decide, without hesitation, that a vegetable is not dead, even when no vegetation appears ; and the proof which we have for its life is, that it remains unaltered ; for, we know, that when a vegetable is dead, it soon changes its appearance, and falls into decay. Thus it appears, that the life of a vegetable consists in two things : 1. In remaining unaltered, when circumstances are unfavourable to vegetation ; 2. In exhibiting the phenomena of vegetation, when circumstances are favourable. When neither of these two things happens, we may say that a vegetable is dead." These remarks, however, throw no light upon the essential nature of vegetable life, which, it is to be apprehended, we must be content to be ignorant of. " The death of plants, if we can judge from the phenomena, is owing to the organs becoming at last altogether unfit for performing their functions, and incapable of being repaired by any of the powers which the vegetative principle possesses.

310. Decomposition of Vegetables.—"The most striking distinction," Dr Thomson remarks, "between the substances belonging to the mineral kingdom, and those which make a part of animals or vegetables, is, that mineral bodies shew little or no tendency to change their nature, and when left to themselves, undergo no spontaneous decompositions; whereas animal and vegetable substances are continually altering, and when left to themselves in favourable circumstances, always run through a regular set of decompositions." During vegetation the constituents of plants are continually changing, and becoming converted into other substances, and after the death of the plant this tendency to change exhibits still greater energy. In the spontaneous decomposition of vegetables the specific gravity of the new compounds formed, is almost always less than that of the old body. Some of them usually fly off in the state of gas or vapour, whence the odour emitted by vegetable bodies during the whole time of their decomposition. When this odour is very offensive, the decomposition is called *putrefaction;* when not offensive, it is called *fermentation;* but the latter term is applied by some to all the stages or degrees of decomposition in vegetables.

311. Fermentation.—Dead vegetable substances containing water, and exposed to a moderate or high temperature, undergo fermentation. Some vegetable principles, as gum, starch, wax, resin, and lignine, though mixed with water, and placed in the most favourable temperature, shew little tendency to change their nature; whereas albumen and fibrine putrefy very rapidly. It is when several of the vegetable principles are mixed together that the fermentation is most remarkable. When gluten is added to a solution of sugar in water, the liquid soon runs into vinegar, or, in certain cases, to alcohol and vinegar. When gluten is mixed with starch and water, alcohol and vinegar usually make their appear-

ance; but the greatest part of the starch remains unaltered. Certain substances also, called *Ferments*, are peculiarly efficacious in exciting fermentation in others. The liquid parts of plants, such as the sap of trees, the juices of fruits, and the decoctions of seeds, roots, or leaves, are those which exhibit this phenomenon in the greatest activity. Three kinds of fermentation are distinguished, the Vinous, Panary, and Acetous. Under the name of *Vinous Fermentation* is included every kind which terminates in the formation of intoxicating liquids. These liquids may be comprehended under two general heads: those obtained from the decoction of seeds, and those obtained from the juices of plants. The liquids of the first class are denominated Beer or Wash, those of the second Wine.

312. VINOUS AND ACETOUS FERMENTATIONS.—The farinaceous seeds of plants being steeped for some time in cold water, are removed from it, and placed in a heap, which after some time is stirred, and then spread out. The seeds, when in the heap, absorb oxygen from the atmosphere, and convert it into carbonic acid; the temperature gradually rises, and the seeds, which had become dry on the surface, become again moist, and exhale an agreeable odour. Germination takes place to a certain extent, and the kernels undergo a change, their glutinous and mucilaginous matter being removed, and the texture rendered loose and friable. The seeds are now dried by artificial heat, and ground in a mill. The *Malt* thus formed is infused in water at a high temperature, and the liquid obtained is called *Wort*. This liquid consists of water holding the farinaceous part of the seeds in solution, and is formed of saccharine matter, starch, mucilage, and some other substances. When sufficiently concentrated by boiling, the wort is put into flat vessels, in an open situation, cooled, and then let into deep vessels where, at a favourable temperature, it ferments, the tem-

perature rises, an internal motion takes place, and carbonic acid gas is emitted. By adding a peculiar substance named yeast, of which the essential element appears to be gluten, the temperature rises, carbonic acid is disengaged, and the saccharine matter is converted into alcohol. The sweet liquor obtained from grapes, apples, gooseberries, currants, and the like, is named *Must*, and that from grapes is composed of water, sugar, jelly, gluten, and tartaric acid. When must is put into a moderately high temperature it ferments, acquires a higher temperature, and emits carbonic acid. In a few days the fermentation ceases, the liquid becomes clear, it has lost its sweet taste, has a less specific gravity, and is known by the name of *Wine*. This liquid consists of water, alcohol, an acid, extractive matter, and colouring matter. The Acetous Fermentation takes place as follows:—Wine or beer kept at a moderately high temperature, with access to the air, gradually becomes thick, acquires a higher temperature, is agitated by an internal motion, and emits a hissing noise. Gradually its motion ceases, filaments attach themselves to the sides and bottom of the vessel, and the liquor, having become clear, is found to be *Acetous Acid*, or vinegar.

313. PUTREFACTION.—Vegetable substances exposed to the air at a moderate temperature, with access to moisture, putrefy, or are decomposed, emitting a disagreeable smell. When moist vegetable matter is accumulated during hot weather, oxygen gas is absorbed and converted into carbonic acid, while the temperature augments, and combustion sometimes takes place. Hay, straw, cotton, and other vegetable matters, have frequently been consumed in this manner. When vegetable matters are composed of carbon, hydrogen, and oxygen only, the smell which they emit is not very offensive; but when azote is present, as in the *Cruciferæ*, they give out a very disagreeable odour; and still more so, when they

also contain sulphur and phosphorus. Lastly, when vegetable bodies putrefy on the surface of the ground, they at last leave a blackish-brown powder, to which the name of *Vegetable Soil*, or *Humus*, is given. This substance, mixing with the soil, and gradually accumulating, is supposed to be subservient to the nourishment of future vegetables.

RECAPITULATION.

305. Are plants liable to numerous diseases? What is Blanching? Gangrene? Canker? Carcinoma? Spotting? What effect is produced by the puncture of insects? What are Smut and Rust? Define Ergot.—306. Do plants differ much in their duration? What are Monocarpean and Polycarpean Plants?—307. How is the age of Dicotyledonous Plants determined? In what manner may an approximation be made to the age of a growing tree? What age was attributed by Adanson to a Baobab thirty feet in diameter?—308. Give some account of the Fall of the Leaf. To what is it owing?—309. Is vegetation the criterion of life? When vegetation has ceased, or been intermitted, how may we judge that the plant yet lives? In what two things does the life of a plant appear to consist? To what is the death of plants owing?—310. What difference exists between minerals and organized bodies as to decomposition?—311. Do vegetable substances vary in the facility with which they decompose? When gluten is added to a solution of sugar in water, what follows? What are Ferments? What is Fermentation? How many kinds of Fermentation are there?—312. Give an account of the Vinous Fermentation, first, in the decoction of the farinaceous seeds of plants; secondly, in the juices of fruits. What takes place in Acetous Fermentation?—313. What is Putrefaction properly so called? State some circumstances relative to it.

EXPLANATION OF THE PLATES.

PLATE I.

Fig.
1. Internal Tissue.
2. Embryo of Pinus Cembra, shewn in a section of the seed, then separate, and magnified.

Fig.
3. Seedling plant of Dombeya, with its four cotyledons.
4. A Garden Bean, shewing the embryo, cotyledons, radicle, plumule, and testa.

PLATE II.

5. Fibrous Root of a Grass.
6. Creeping stem of Mint.
7. Fusiform root of a Radish, with seminal and primordial leaves.
8. Premorse Root.
9. Tuber of the Potato.
10. Didymous Tubers of Orchis.
11. Palmate Tubers of Orchis.
12. Fasciculate Tubers of Satyrium.
13. Cormus of Crocus.
14. Tunicated Bulb of Allium.
15. Squamous Bulb of Lilium.
16. Granuliferous Root of Saxifraga.

PLATE III.

17. Dichotomous Stem of Chlora.
18. Scaly Stem of Orobanche.
19. Clinging Stem of Ivy.
20. Twining Stem of Honeysuckle.
21. Twining Stem of Convolvulus.
22. Runner of Strawberry.
23. Determinately-branched Stem.
24. Buds of Lonicera cœrulea.
25. Bud of Horse Chestnut.

PLATE IV.

26. Tufted Leaves.
27. Imbricated Leaves.
28. Decussate Leaves.
29. Distichous Leaves of Yew.
30. Unilateral Leaves.
31. Peltate Leaf of Nasturtium.
32. Amplexicaul Leaf.
33. Perfoliate Leaf.
34. Sheathing Leaf of a Grass.
35. Equitant Leaves.
36. Decurrent and Spinous Leaf.
37. Flower-bearing Leaf of Ruscus.

PLATE V.

38. Orbicular Leaf.
39. Roundish Leaf.
40. Ovate Leaf.
41. Obovate Leaf.
42. Elliptical Leaf.
43. Spathulate Leaf.
44. Wedge-shaped Leaf.
45. Lanceolate Leaf.
46. Linear Leaf.
47. Needle-shaped Leaf.
48. Triangular Leaf.
49. Quadrangular and Abrupt Leaf.
50. Deltoid Leaf.
51. Rhomboidal Leaf.
52. Kidney-shaped Leaf.
53. Heart-shaped Leaf.
54. Crescent-shaped Leaf.
55. Sagittate Leaf.
56. Hastate Leaf.
57. Panduriform Leaf.
58. Runcinate Leaf.
59. Lyrate Leaf.
60. Cleft Leaf.
61. Three-lobed Leaf.
62. Sinuate Leaf.
63. Partite Leaf.
64. Laciniate Leaf.

PLATE VI.

65. Palmate Leaf.
66. Pinnatifid Leaf.
67. Doubly Pinnatifid Leaf. Pectinate Leaf.
69. Unequal Leaf.
70. Erose Leaf.
71. Retuse Leaf.
72. Emarginate Leaf.

Fig.
73. Acuminate Leaf.
74. Acute Leaf.
75. Thorn-pointed Leaf.
76. Cirrose Leaf.
77. Spinous Leaf.
78. Ciliate or Fringed Leaf.
79. Toothed Leaf.
80. Serrate Leaf.
81. Crenate Leaf.

PLATE VII.

82. Doubly Crenate Leaf.
83. Jagged Leaf.
84. Wavy Leaf.
85. Plaited Leaf.
86. Undulated Leaf.
87. Curled or Crisp Leaf.
88. Angulinerved Leaf.
89. Curvinerved Leaf.
90. Three-nerved Leaf.
91. Pinninerved Leaf.
92. Triply-nerved Leaf.
93. Cylindrical and Pointed Leaf.
94. Semicylindrical Leaf.
95. Awl-shaped Leaf.
96. Doubly tubular Leaf of Lobelia.
97. Canaliculate Leaf.
98. Dolabriform or Hatchet-shaped.
99. Three-edged Leaf.
100. Four-edged Leaf.

PLATE VIII.

101. Diversiform Leaves of Mimosa verticillata.
102. Hooded Leaf of Sarracenia.
103. Appendiculate Leaf of Dionæa.
104. Articulated Leaf.
105. Binate Leaf.
106. Ternate Leaf.
107. Interruptedly-pinnate Leaf.
108. Lyrately-pinnate Leaf.
109. Verticillately-pinnate Leaf.
110. Auriculate Leaf.
111. Compound Pinnate Leaf.
112. Doubly Compound, or Biternate Leaf.
113. Thrice Compound, or Triternate Leaf.
114. Pedate Leaf of Helleborus.

PLATE IX.

115. Stipules, also Binate Leaf, with a tendril.
116. Stipules & Pinnate Leaf of Rosa.
117. Bractea of Tilia.
118. Bracteas of Lavandula.
119. Spinous Bracteas of Atractylis.
120. Thorns of Hippophaë.
121. Aculei, or Prickles of Rosa.
122. Cirrus, or Clasper.
123. Glandule-tipped Hairs of Rosa.
124. Hairs.
125. Bristles.

PLATE X.

126. Spurious Verticil of Lamium.
127. Verticillate Flowers and Leaves of Hippuris.
128. Raceme of Currant.
129. Spike, unilateral, of Ophrys spiralis.
130. Spicate Raceme of Veronica spicata.
131. Spikelet of Bromus.
132. Corymb.
133. Corymbose Fasciculus of Achillæa.
134. Fasciculus of Dianthus Armeria.
135. Capitulum, or Condensed Raceme.
136. Sertule, or Simple Umbel.
137. Simple Umbel and Involucrum.
138. Compound Umbel, with general and partial Involucres.

PLATE XI.

139. Cyme of Laurustinus.
140. Panicle of Avena.
141 Thyrsus.
142. Calyx of Dianthus.
143. Involucrum of Anemone.
144. Sori and Indusia of a Fern.
145. Indusium and Sorus; also, Capsule and Ring of a Fern.
146. Catkin of Hazel, with separate bractea and stamens.

PLATE XII.

Fig.
147. Spatha, with the calyx and crown, of Narcissus.
148. Husks of a grass.
149. Awn of a grass.
150. Scaly sheath and capsule of Pterogonium Smithii.
151. Calyptra of the same.

Fig.
152. Organs of Reproduction of Jungermannia epiphylla.
153. Volva of an Agaricus.
154. Radical Volva.
155. Hypocrateriform Corolla.
156. Cruciform Corolla.
157. Petal, with claw and lamina.
158. Perianth of Butomus.

PLATE XIII.

159. Campanulate Corolla.
160. Funnel-shaped Corolla.
161. Labiate or Ringent Corolla.
162. Personate or Masked Corolla.
163. Papilionaceous Corolla.
164. Vexillum or Standard.
165. Ala or Wing.
166. Carina or Keel.
167. Diadelphous Stamens and Style.
168. Incomplete Corolla of Rittera.
169. Regular-flowered variety of Linaria vulgaris.
170. Spurred Calyx of Tropæolum.
171. Spurred Petal of Aquilegia.
172, 173. Nectary of Epimedium.

PLATE XIV.

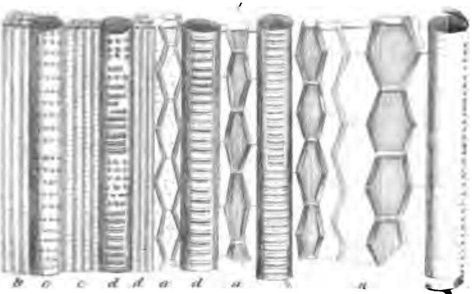
174. Nectaries of Aconitum.
175. Fringed Nectaries of Parnassia.
176. A Stamen: *a*, filament; *b*, anther.
177. A Pistil: *a*, ovarium; *b*, style; *c*, stigma.
178. Capsule of a Mesembryanthemum open and shut.
179. Section of Capsule of Datura.
180. Siliqua.
181. Silicula.
182. Legumen.

PLATE XV.

183. Drupa of Cherry.
184. Pomum of Pyrus.
185. Berry of Ribes.
186. Eterio of Rasp.
187. Berry of Passiflora.
188. Cone or Strobilus of Larch.
189. Capsule of Splachnum.
190. Reproductive Organs of Moss.
191. The same magnified.
192. Reproductive Organs of Moss.
193. Sporule of Moss germinating.
194. Sporule of Moss more advanced.

PLATE XVI.

195. Young Moss, Gymnostomum.
196. Young Moss, Funaria hygrometrica.
197. Powdery Wart of a Lichen.
198. Section of Apothecium of a Lichen.
199. Section of the Seed of the Date.
200. Section of the Albumen of Zamia, with the embryo.
201. Rough Pericarps of Cynoglossum.
202. Pericarp of a Carex.
203. Fruit of Afzelia.
204. Fruit of Tragopogon with stipitate feathery pappus.
205. Tail of the Fruit of Dryas.
206. Beaked Fruit of Scandix.
207. Winged Fruit of Embothrium.
208. Section of Recepacle of Bellis.
209. Cellular Receptacle of Onopordum.
210. Ligulate or Semiflosculous Corolla of Dandelion, with stamens and pistil.
211. Ligulate Corolla of Bellis, with pistil only.
212. Tubular Corolla of Bellis, with stamens and pistil.
213. Capsule of a Moss, with the Peristome and Operculum.
214. Portion of the Peristome magnified.

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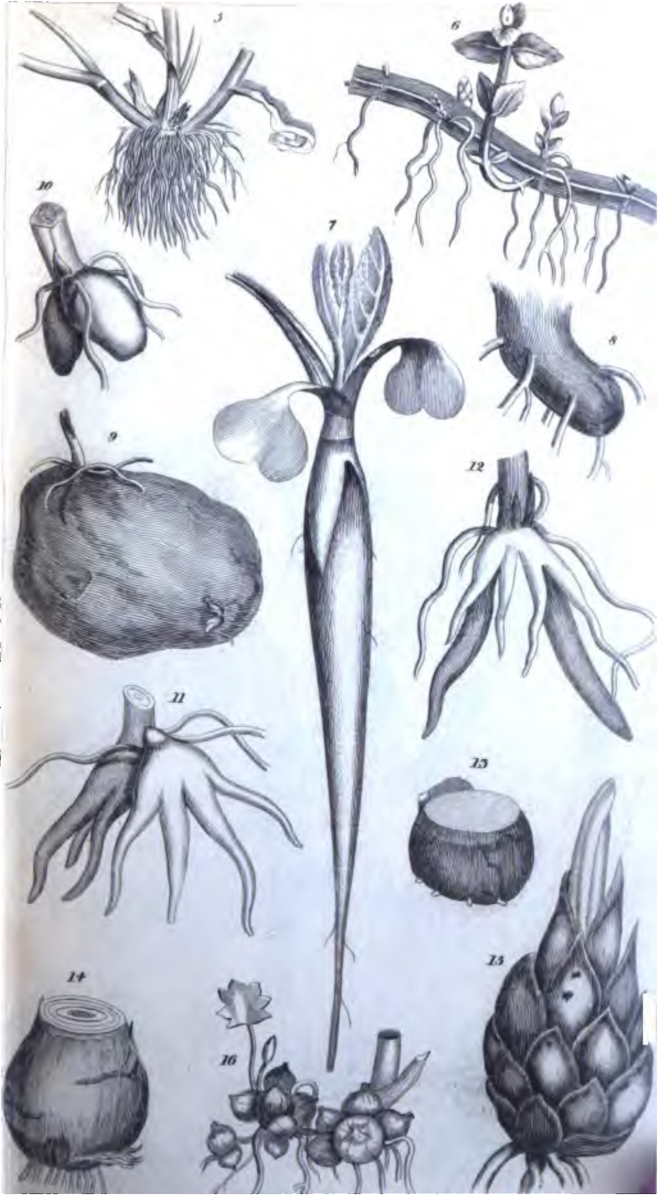
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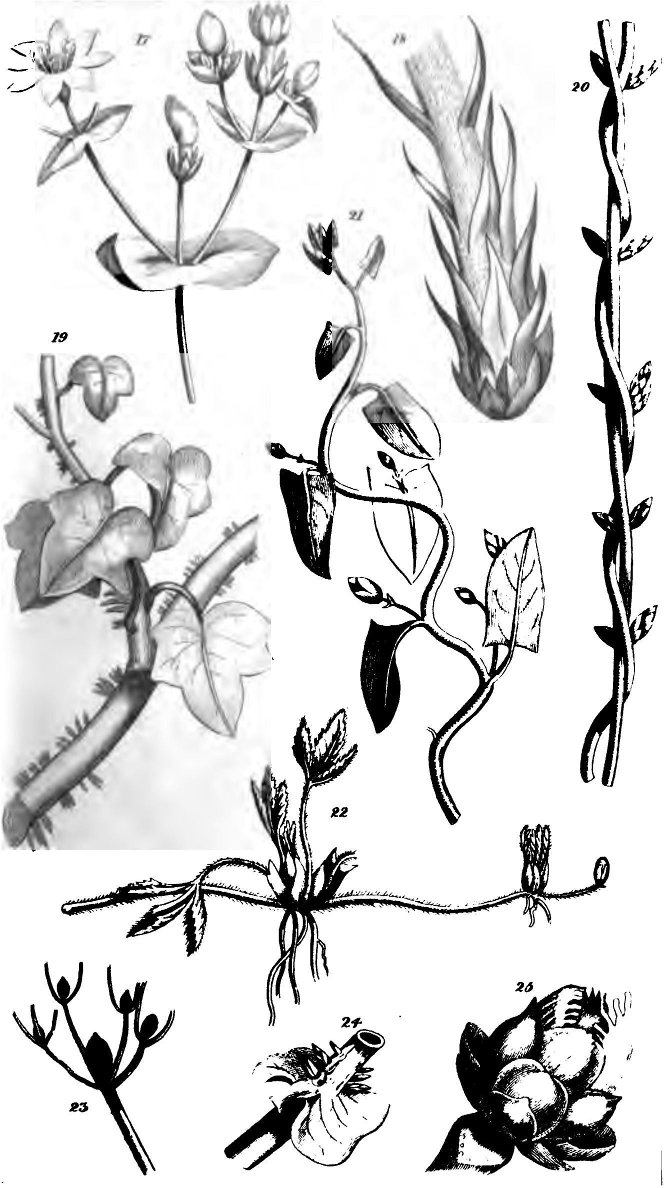
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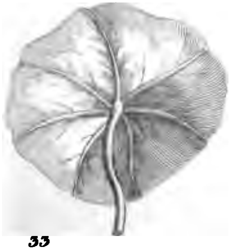
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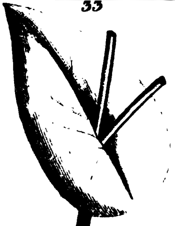
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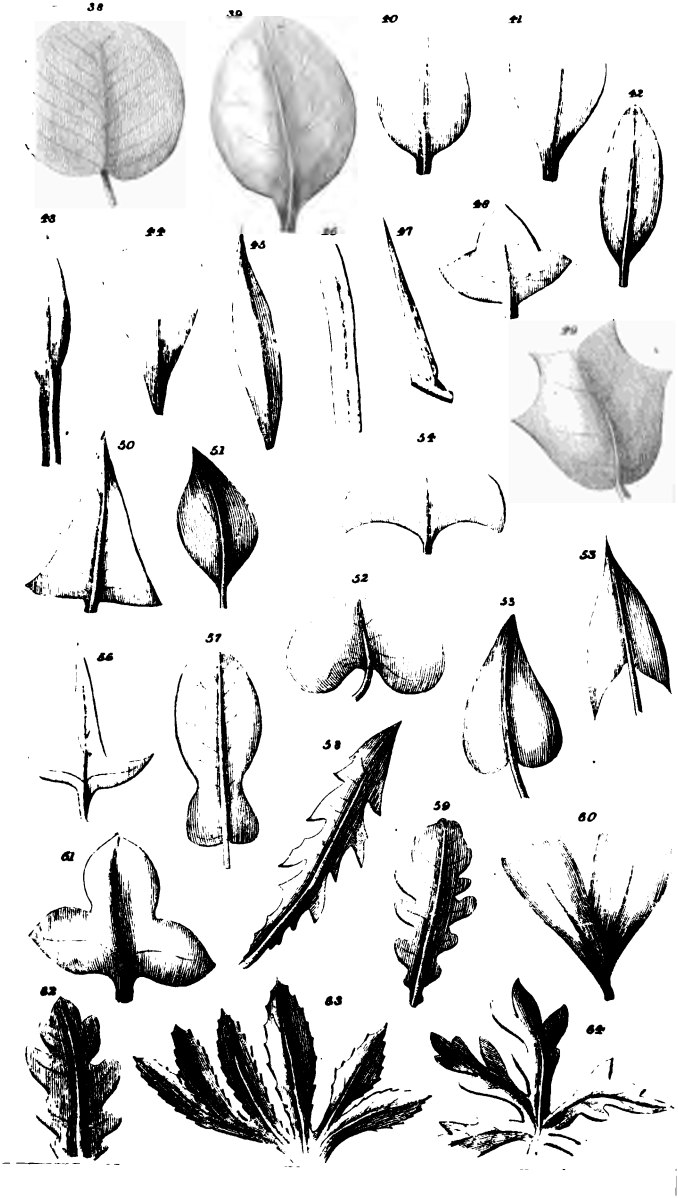

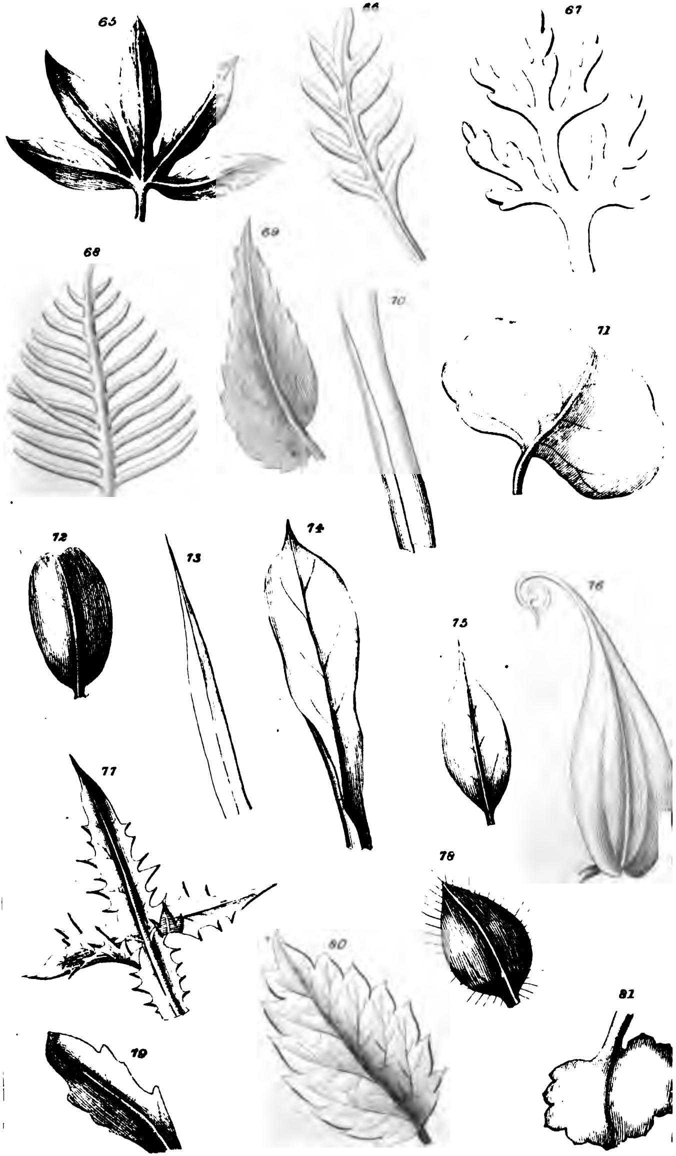
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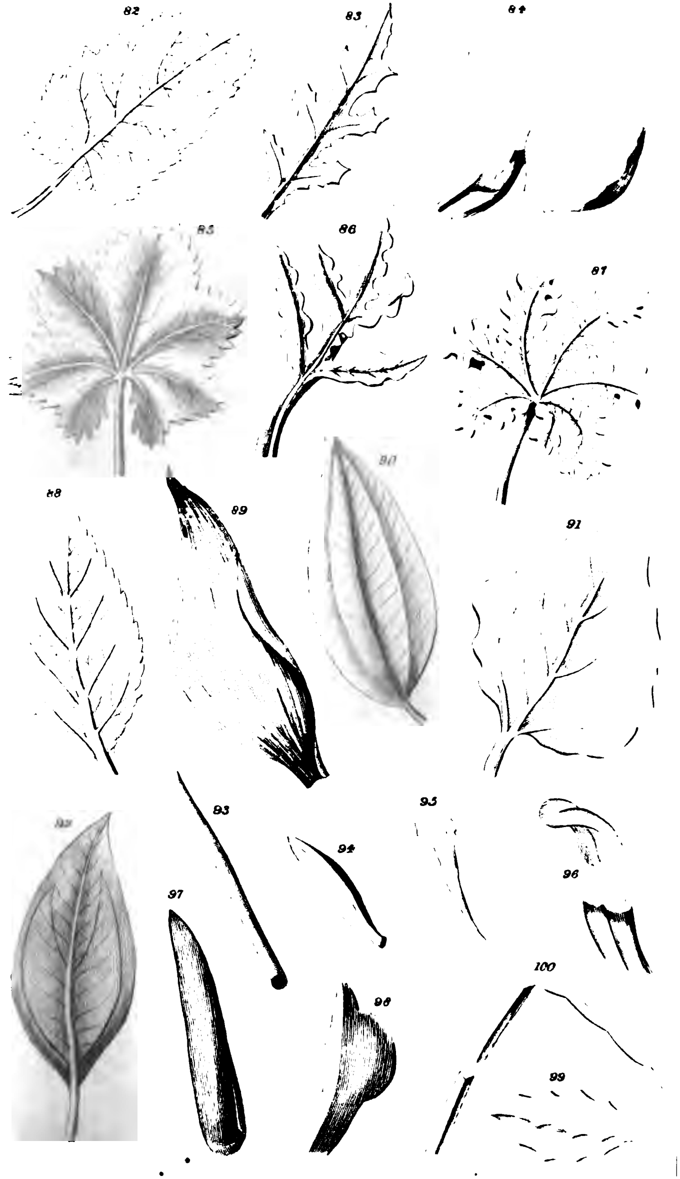
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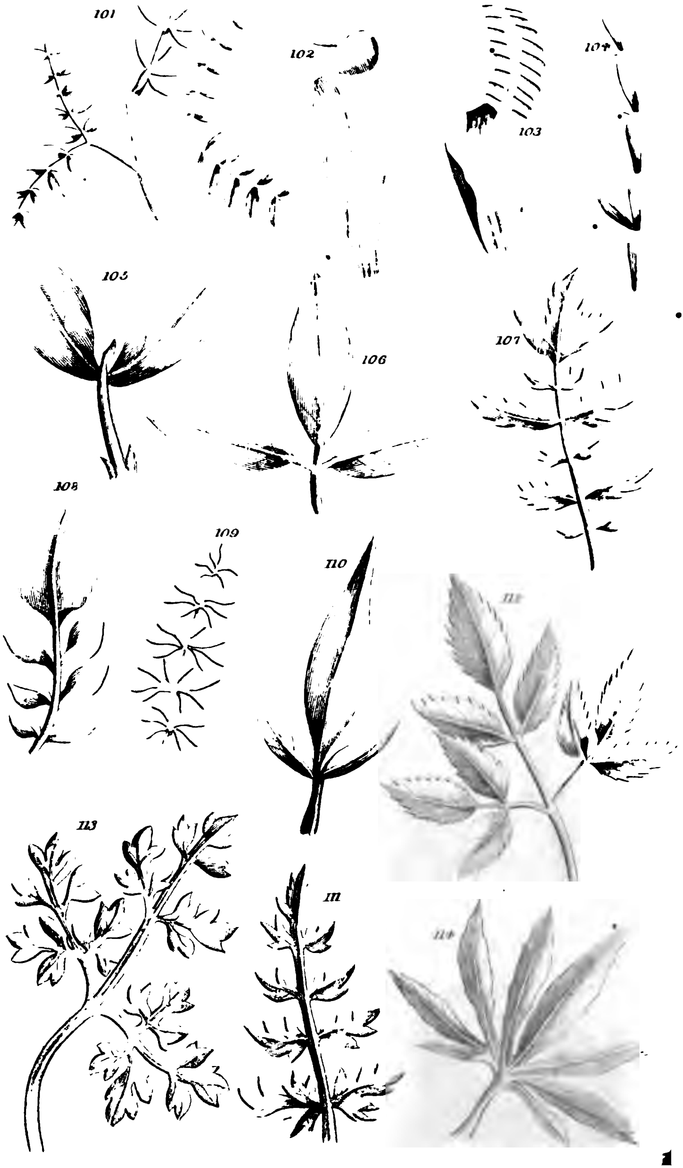
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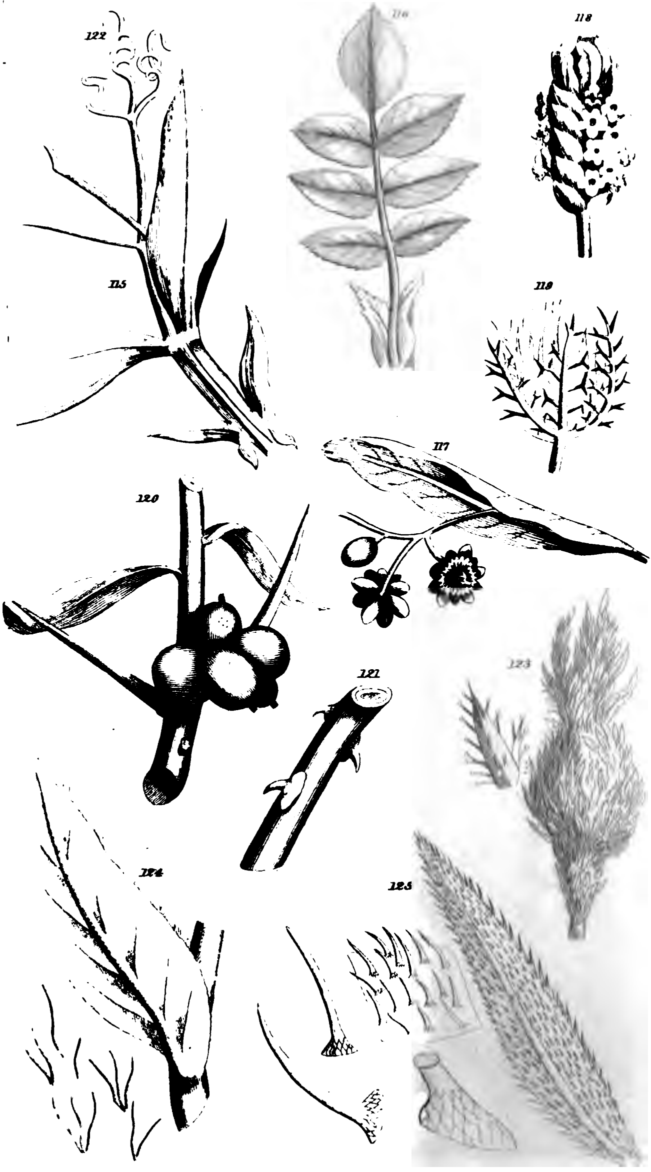
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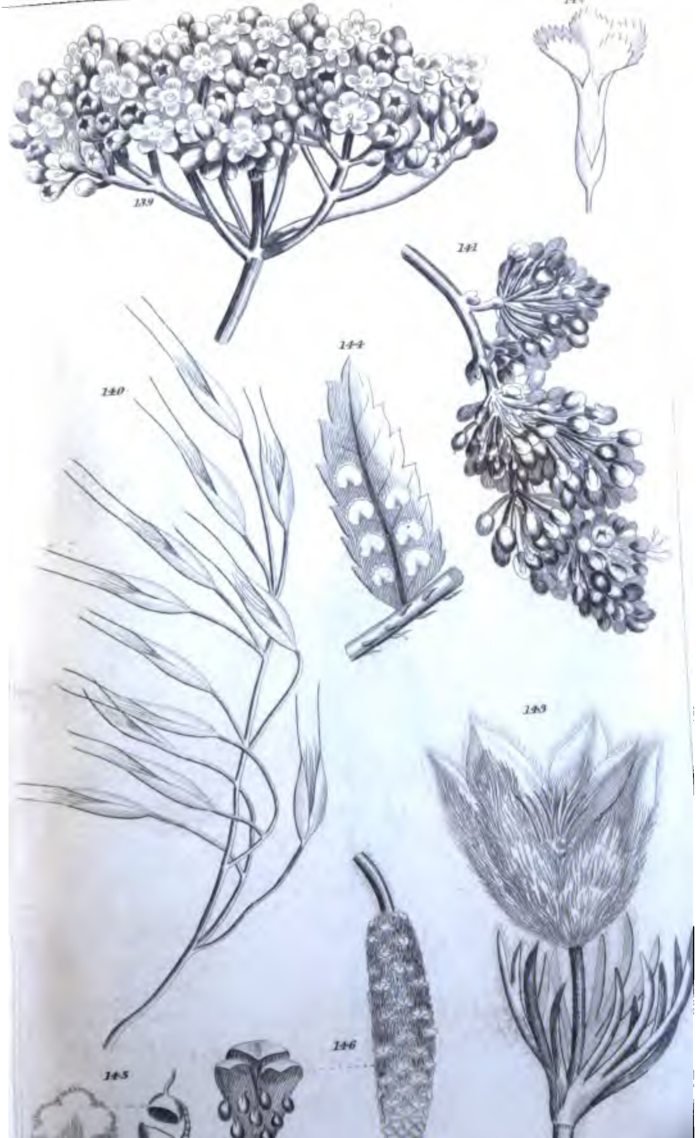
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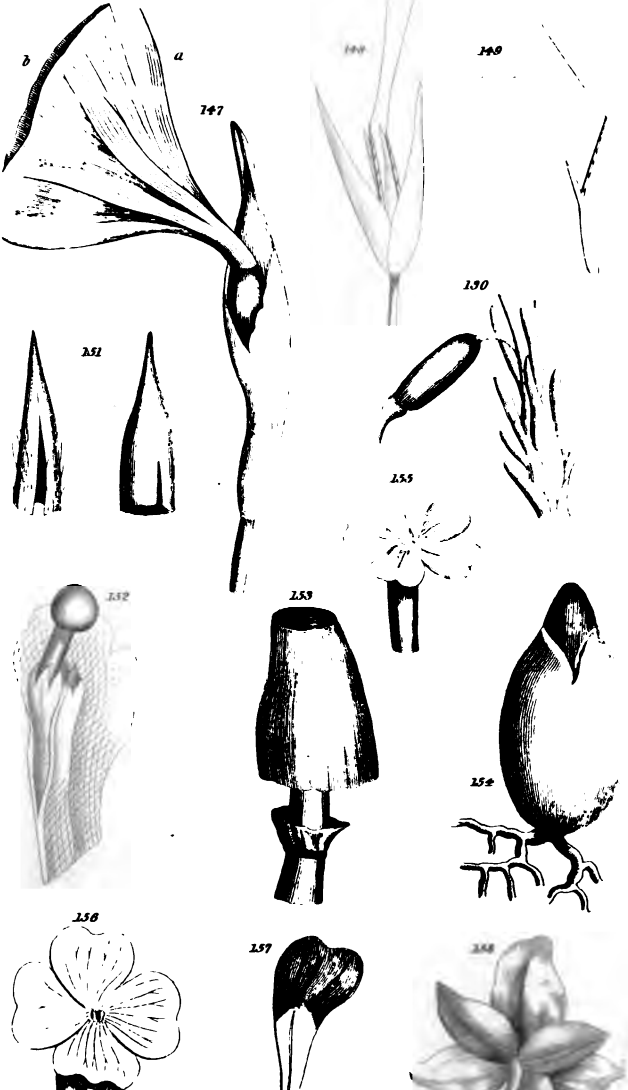

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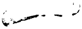

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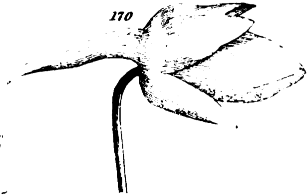

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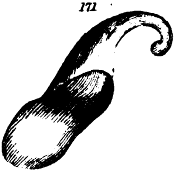

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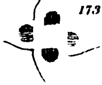

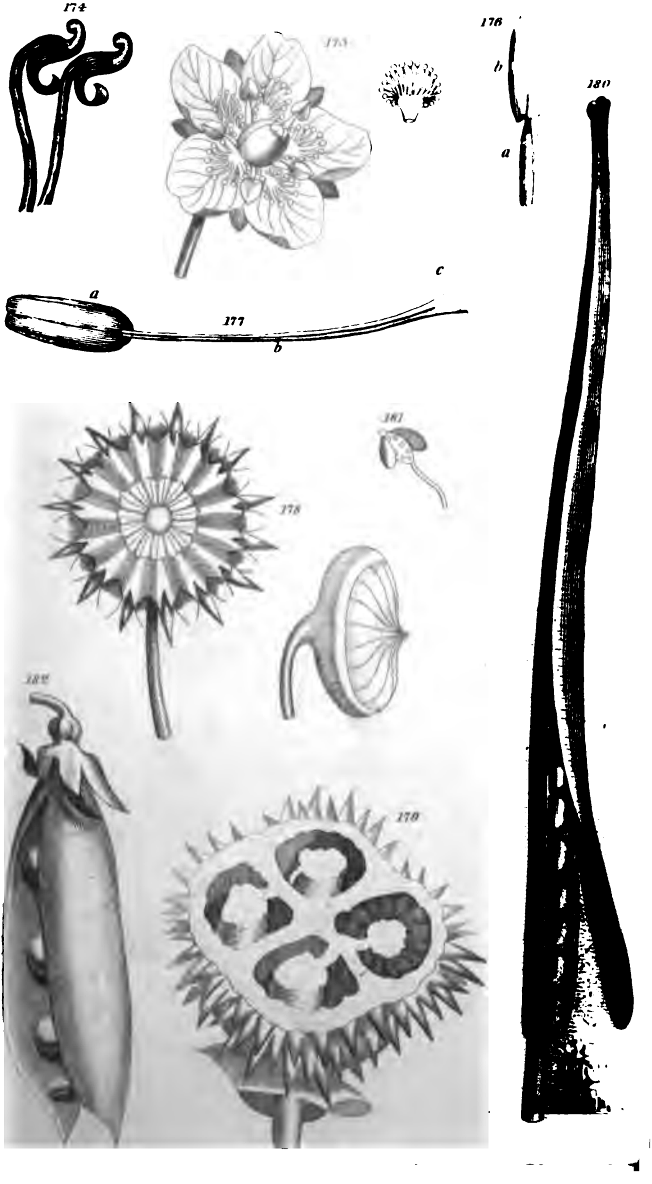
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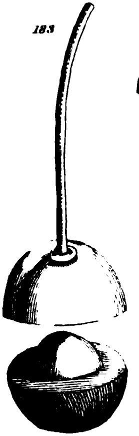

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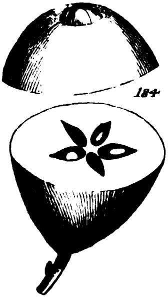

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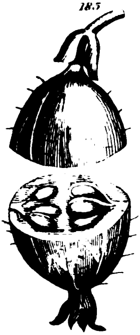

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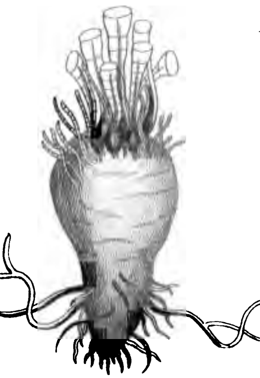

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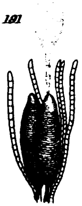

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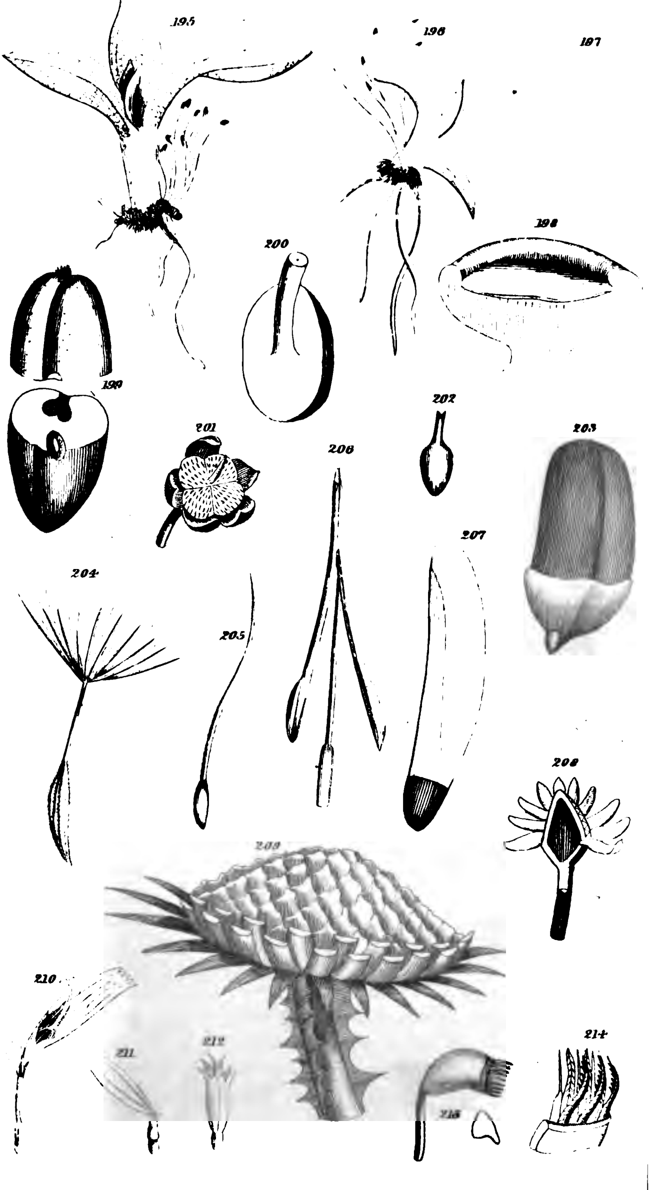
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APPENDIX.

REMARKS ON CLASSIFICATION, WITH AN OUTLINE OF THE SYSTEMS OF LINNÆUS AND JUSSIEU.

General Idea of Classification.—Natural objects being so numerous that it is impossible for the most tenacious memory to retain even the names of them, it is necessary to arrange them into groups, of various degrees of extent and subordination, § 33. All the individuals that agree together in possessing the essential common characters or features form collectively a Species. Species agreeing together in certain characters of a more general kind, form a Genus. Genera placed together, on the same principle, constitute an Order, and orders unite to form a Class. Groups of these kinds are common to all modes of arrangement, or systems. But the disposition of the groups may be variously managed. Thus, plants may be placed according to some character arbitrarily fixed upon, as the number of the petals, or stamens; or they may be placed agreeably to their general affinities, so that genera nearly allied in their whole organization, may form families that may readily be recognised as natural. Hence a distinction of systems into Artificial and Natural. This subject, to which the name of Taxonomy is given, will be treated of in another volume. All that is intended here is to present a tabular outline of the two most celebrated systems, those of Linnæus and Jussieu.

System of Linnæus.—In the arrangement proposed by the illustrious Linnæus, which is professedly artificial, plants are disposed according to the number, proportion, and connexion, of the stamens and pistils. The classes are twenty-four.

I. *Monandria.* Plants of which each flower has a single stamen.
II. *Diandria.* Two stamens.
III. *Triandria.* Three stamens.
IV. *Tetrandria.* Four stamens.
V. *Pentandria.* Five stamens.
VI. *Hexandria.* Six stamens.
VII. *Heptandria.* Seven stamens.
VIII. *Octandria.* Eight stamens.
IX. *Enneandria.* Nine stamens.
X. *Decandria.* Ten stamens.
XI. *Dodecandria.* About twelve stamens.

In the next two classes, the stamens are numerous, but are differently inserted.

XII. *Icosandria.* Twenty or more stamens attached to the calyx.
XIII. *Polyandria.* Twenty or more stamens attached to the top of the peduncle.

The next two are founded on the number and relative length of the stamens.

XIV. *Didynamia.* Four stamens, of which two are longer.
XV. *Tetradynamia.* Six stamens, of which four are longer.

In the next three, the filaments of the stamens cohere.

XVI. *Monadelphia.* Filaments coherent, so as to form a tube.
XVII. *Diadelphia.* Filaments coherent, in two sets.
XVIII. *Polyadelphia.* Filaments coherent, in three or more sets.

In the nineteenth class, the filaments are free, but the anthers united.

XIX. *Syngenesia.* Stamens five, having the anthers united.

In the next, the stamens and pistils are united.

XX. *Gynandria.* Stamens adherent to the pistil.

The next three are founded upon the separation of the reproductive organs.

XXI. *Monœcia.* Flowers having stamens only, and flowers having pistils only, on the same individual plant.

XXII. *Diœcia.* Flowers having stamens only on one individual, and flowers having pistils only on another individual, of the same species.

XXIII. *Polygamia.* Stameniferous flowers, pistilliferous flowers, and perfect flowers, on the same individual, or on two or three individuals of the same species.

The last class comprehends all the plants that are destitute of flowers.

XXIV. *Cryptogamia.*

The classes are divided into orders, according to the number of the pistils. Thus in the fifth class, Pentandria, the orders are *Monogynia, Digynia, Trigynia,* &c. Sometimes the nature of the pericarp, the number of the stamens, and some other circumstances, are employed to characterize the order.

SYSTEM OF JUSSIEU.—The system of Linnæus often places together plants which have no natural affinity; but in arrangements intended to preserve the mutual relations of plants, they are disposed in natural groups, although it is impossible, in linear series, to exhibit all the connexions of these groups. A natural system, artificial in some of its parts, is that of Jussieu, who divides all plants primarily into three groups:—

I. ACOTYLEDONS. II. MONOCOTYLEDONS. III. DICOTYLEDONS.

These three primary groups are disposed into fifteen classes, characterized by the insertion of the stamens, they being hypogynous, perigynous, or epigynous. Thus:

I. ACOTYLEDONES.

I. *Acotyledonia.*

II. MONOCOTYLEDONES.

II. *Monohypogynia.* Stamens hypogynous.
III. *Monoperigynia.* Stamens perigynous.
IV. *Monoepigynia.* Stamens epigynous.

III. DICOTYLEDONES.

* Apetalous.

V. *Epistaminia.* Stamens epigynous.
VI. *Peristaminia.* Stamens perigynous.
VII. *Hypostaminia.* Stamens hypogynous.

** Monopetalous.

VIII. *Hypocorollia.* Stamens hypogynous.
IX. *Pericorollia.* Stamens perigynous.
X. *Synantheria.* Stamens epigynous, anthers united.
XI. *Corisantheria.* Stamens epigynous, anthers free.

*** Polypetalous.

XII. *Epipetalia.* Stamens epigynous.
XIII. *Hypopetalia.* Stamens hypogynous.
XIV. *Peripetalia.* Stamens perigynous.

XV. *Declinia.* Monœcious, diœcious, and polygamous plants.

Under these fifteen classes, Jussieu included one hundred orders or families; such as, Fungi, or mushrooms; Algæ, or seaweeds; Gramineæ, or grasses; Junci, or rushes; Labiatæ, or plants with ringent corollas; Umbelliferæ, those having the inflorescence an umbel; Coniferæ, those of which the fruit is a strobilus.

This system is not now in use; but the principles on which it is founded are those according to which the natural arrangements of De Candolle, Lindley, and others, are constructed. Of these mention will be made in a separate Treatise, in which it is proposed to present an Arrangement of the Natural Families of Plants.

GLOSSARY.

Abrupt Leaf. Having its extremity cut off, as it were, by a transverse line, 65.

.... Root. Fleshy, and terminating abruptly, as if the lower part had been cut off, 29.

Abruptly Pinnate Leaf. Without a terminal leaflet, 70.

Accumbent Cotyledons. Folded, with their edges to the radicle, 125.

Achenium. A one-seeded, indehiscent fruit, having the pericarp free, 120.

Acorn. A one-celled, indehiscent, dry fruit, having its base enveloped in a cupule, 121.

Acotyledonous Plants. Destitute of seeds furnished with cotyledons, 26.

Acrogenous Plants. Of which the stem increases by the summit, 131.

Aculei. Prickles, or strong, rigid hairs, of complex structure, 21.

Acuminate Leaf. Taper-pointed, 65.

Acute Leaf. Sharp-pointed, 65.

Adnate Anther. Attached by the back, 104.

Adpressed Branches. Forming a very acute angle with the stem, 53.

Æstivation. The manner in which the parts of the flower are arranged previous to expansion, 86.

Aggregated Fruits. Formed of several series of simple ovaria, 119.

Air-Cells. Cavities containing air, 17.

ALÆ. The wings, or two lateral petals of a papilionaceous corolla, 97.

ALTERNATE LEAVES. Coming off one by one, 56.

.... PETALS. Arranged alternately with reference to the sepals, 98.

ALTERNATELY PINNATE LEAF. With alternate leaflets, 70.

.... BRANCHED STEM. With the branches coming off one after the other, 38.

APOCARPOUS FRUIT. Having the carpels distinct, 117.

APOTHECIA. Organs containing the sporules of Lichens, 130.

APPENDICULATE ANTHERS. Having appendages at their summit, 104.

APPLE. A fruit composed of several membranous carpels, imbedded in a fleshy mass, 121.

ARACHNOID. Covered with long, soft, entangled filaments, resembling a spider's web, 10.

ARILLUS. Expanded pedicel of the seed, 122.

ARTICULATED LEAF. Of which the petiole is contracted at the base, 58.

ASCENDING STAMENS. Directed upward, 101.

.... STEM. Rising obliquely, 39.

.... STYLE. Curved upwards, 111.

AMPLEXICAUL LEAF. Embracing the stem all round, 59.

ANALOGIES OF PLANTS AND ANIMALS. Their mutual resemblances in structure and function, 8.

ANGULAR STEM. Having more than five angles, 40.

ANIMAL. A living body possessed of sensibility and voluntary motion, 6.

ANGULINERVED LEAVES. With branched nerves, 61.

ANOMALOUS COROLLA. Of five irregular petals, 98.

ANNULAR DUCTS. Of which the spiral fibre is broken into rings, 16.

ANNULUS. Ring of membrane on the stalk of mushrooms, being the remains of the volva, 130.

ANTHER. A membranous sac containing pollen, 102, 103.

ANTHERS, ADNATE. Attached by the back, 104.

.... APPENDICULATE. Having appendages at its summit, 104.

ANTHER, BASIFIXED. Attached by the base, 103.
..........., BILOCULAR. Two-celled, 103.
..........., COHERENT. United by their edges, 105.
..........., DIDYMOUS. Of two spheroidal lobes, 104.
..........., DEHISCENCE. Their mode of opening, 104.
..........., EXTRORSE. Having the face directed outwards, 104.
..........., INNATE. Attached by the base, 104.
..........., INTRORSE. Facing the axis of the flower, 104.
..........., MEDIIFIXED. Attached by the back, 103.
..........., QUADRILOCULAR. Four-celled, 103.
..........., UNILOCULAR. One-celled, 103.
..........., VERSATILE. Attached by a single point, so as to turn easily, 104.

ANTHOPHORE. Columnar receptacle bearing the petals and stamens, 114.

ANTHODIUM. Numerous sessile flowers on a broad receptacle, enclosed within an involucre, 82.

APPENDICULATE ANTHERS. Having appendages at their summit, 104.

BARK. Outer layers of a dicotyledonous woody stem, 46.

BASIFIXED ANTHER. Attached by its base, 103.

BASAL STYLE. Arising from the base of the ovary, 111.

BEARDED. Having long hairs placed in tufts, 20.

BELL-SHAPED COROLLA. Of the form of a bell, 94.

BERRY. An indehiscent, many-seeded, pulpy fruit, 121.

BIFID LEAF, SEPAL, OR PETAL. Slit to a small extent, 65.

BIJUGATE LEAF. With two pairs of leaflets, 70.

BLISTERY LEAF. Much wrinkled, 67.

BILOCULAR ANTHER OR FRUIT. Of two cells, 103, 117.

BIPINNATE LEAF. Compound, pinnate, with the pedicels also pinnate, 71.

BIPINNATIFID LEAF. Pinnatifid, with the segments similarly divided, 64.

BIPARTITE LEAF, OR PETAL. Slit to a considerable extent, or more than half way, 65.

BITERNATE LEAF. Twice ternate, 71.

BOTANY. The science which treats of plants, 1, 3.

Brachiate Stem. With the branches spreading in four directions, 38.

Bractea. A kind of leaf connected with the flower, or attached to its peduncle, 78.

Branched Root or Stem. Divided into branches, 31.

Branches. Divisions of the stem or root, 42.

............, **Adpressed.** Forming a very acute angle with the stem, 53.

............, **Divergent.** Coming off at an angle of about forty degrees, 53.

............, **Patent, or Spreading.** Coming off at a right angle, 53.

Bristly. With conical, short, stiff hairs, 20.

Brittle Stem. Stiff, but easily broken, 38.

Bud. A body composed of the rudiments of some of the organs, 51.

Buds, Aerial. Those developed above the surface of the ground, 51.

......, **Flower.** Giving rise to flowers, 52.

......, **Irregular, or Adventitious.** Accidental, 52.

......, **Leaf.** Giving rise to leaves, 52.

......, **Leafy.** Of which the scales are imperfect leaves, 51.

......, **Petiolar.** Of which the scales are formed by the persistent bases of the leaf-stalks, 51.

......, **Mixed.** Giving rise to leaves and flowers, 52.

......, **Regular.** Placed in the axils of leaves, or at the end of twigs, 52.

......, **Stipular.** When enveloped by the stipules, 51.

......, **Subterranean.** Developed under ground, 53.

Bulb. A kind of bud, composed of fleshy scales, 53.

......, **Coated or Tunicated.** With the outer scales thin, and forming each a continuous covering, 53.

......, **Scaly.** With the scales distinct, fleshy, and imbricated, 54.

Bulbiferous Root. Fibrous, surmounted by a disk and bulb, 30.

Bulbils. Small buds developed on the stem or other parts, and giving rise to new individuals, 54.

CADUCOUS LEAVES. Falling off soon after expansion, 72.

.... STYLE. Falling off after fecundation, 111.

CALYPTRA. Covering of the capsule in mosses, 129.

CALYX. The outer verticil of the perianth, 88.

CALYX, ANGULAR. With prominent longitudinal lines, 91.

.... CAMPANULATE. Bell-shaped, 90.

.... COMPRESSED. Flattened, 90.

.... CUP-SHAPED. Concave like a cup, 90.

.... GAMOSEPALOUS. Of a single piece, or having the sepals united, 89.

.... GROOVED. With numerous longitudinal ridges and grooves, 91.

.... INFLATED. As if blown out like a bladder, 90.

.... MONOSEPALOUS. Of one piece, 89.

.... POLYSEPALOUS. Of several distinct sepals, 91.

.... SPURRED. Having a prolongation at the base, 91.

.... TUBULAR. Narrow and elongated, 90.

.... TWO-LIPPED. With its limb divided into two principal segments, 91.

.... URCEOLATE. Swelled, with the mouth narrow, 90.

CAMPANULATE CALYX OR COROLLA. Bell-shaped, 94.

CANALICULATE LEAF. Having a longitudinal groove along its upper face, 67.

CAPILLARY FILAMENT OR STIGMA. So slender as to resemble a hair, 102, 112.

.... ROOT. Of hair-like fibres, 31.

CAPITATE STIGMA. Spherical or roundish, 112.

CAPITULUM. A very short raceme, of which the flowers are placed close together, 81.

CAPSULE. A dry, dehiscent, many-seeded pericarp, 121.

CARCERULUS. A many-celled, dry, indehiscent fruit, surrounding a common axis, 120.

CARINA. The keel, formed of the two lower petals of a papilionaceous corolla, 97.

CARINATE LEAF. Having a longitudinal ridge beneath, 67.

CARPEL. Modified leaf, forming the ovary, or seed-vessel, 117.

CARPOPHORE. A columnar receptacle bearing the fruit, 114.

CARPOLOGY. Description of fruits, 118.

CARYOPSIS. A one-seeded, indehiscent fruit, having the pericarp and seed united, 120.

CARYOPHYLLACEOUS COROLLA. Of five long-clawed petals, 97.

CATKIN. A spike, of which the flowers are bracteas, 81.

CAUDEX. The body or principal part of the root, 27.

CUTICLE. Base of the stem in the germinating seed, 124.

CAULINE LEAVES. Those attached to the stem, 56.

.... PEDUNCLE. Arising from the stem, 77.

CELLULAR. Composed of minute cells or vesicles, 12.

.... TISSUE. That which is composed of cellules, 12.

........................, FIBROUS. Of which the cellules are partly composed of fibre, 13.

........................, MEMBRANOUS. Of which the cellules are entirely composed of membrane, 13.

........................, WOODY. Of which the elongated cellules are composed of woody matter or lignine, 13.

CENTRIFUGAL GROWTH. Radiating from a centre, 131.

CHALAZA. The place at which the secundine is attached to the primine, 123, 182.

CHANNELLED LEAF OR PETIOLE. Having a longitudinal groove above, 67, 59.

.... With deep unequal chinks, 42.

CILIATED. Margined with hairs, in the manner of eyelashes, 20.

CIRCINATE. Rolled up, 74.

CIRROSE LEAF. Terminated by a cirrus or tendril, 65.

CIRRUS. A filiform prolongation of the petiole, 73.

CLASSIFICATION OF PLANTS. Their arrangement into genera, families, orders, and classes, 24.

CLAVIFORM FILAMENT. STIGMA, STYLE, OR PETIOLE. Club-shaped, or enlarged upwards, 59, 102, 111.

CLAW. The lower narrow part of a petal, 93.

CLEFT CALYX OR COROLLA. With divisions reaching nearly to the middle, 64, 90.

.... LEAF. With narrow slits, 64.

CLIMBING STEM. Ascending by tendrils, 39.

CLINGING STEM. Clinging to another body by fibres, 39.
CLOSE-PRESSED LEAVES. Pressed close to the stem, 57.
CLUB-SHAPED, STIGMA, STYLE, OR PETIOLE. Enlarged upwards, 102, 111, 59.
COATED BULB. Having the scales continued all round, 53.
COHERENT ANTHERS. United by their edges, 105.
COLLECTIVE FRUITS. Having the floral envelopes or bracteas enlarged and thickened, 121.
COLEOPTILE. Sheath of the plumule in monocotyledonous seeds, 126.
COLEORHIZA. Sheath of the radicle in monocotyledonous seeds, 126.
COLUMELLA. Central part of the capsule in mosses, 129.
CORTICAL LAYERS. The outer bark, 46.
CONICAL ROOT. Having the form of a reversed cone, 31.
COMPOUND FRUITS. Of several united ovaria, 120.
.... LEAVES. Of several distinct leaflets, 59.
.... ORGANS. Those composed of several varieties of the elementary tissue, 22.
COMPRESSED LEAF. Laterally flattened, 68.
.... STEM. Flattened on two opposite sides, 39.
COMOSE ROOT. Of slender, much-branched filaments, 31.
CONCAVE LEAF. Having the upper margin concave, 67.
CONDUPLICATE. Folded lengthwise, 74.
CONE. An enlarged and hardened catkin, 121.
CONICAL LEAF. Having the form of a cone, 68.
CONJUGATE LEAF. With one pair of leaflets, 70.
CONNATE LEAVES. Two opposite sessile leaves united by their basis, 59.
CONNECTIVE. A part interposed between the cells of the anther, 103.
CONVEX LEAF. Having its upper surface convex, 66.
CORDATE LEAF. Heart-shaped, 68.
CORIACEOUS LEAF. Thick and dense, 67.
CORKY STEMS. With the bark of the nature of cork, 42.
CORMUS. Enlarged base of the stem in the Crocus and other monocotyledonous plants, 33.
COROLLA. The inner verticil of the perianth, 93.

COROLLA, CAMPANULATE. Bell-shaped, 94.

............, CARYOPHYLLACEOUS. Of five petals, of which the claws are elongated, 97.

............, CRUCIFORM. Of four long-clawed petals, arranged in pairs crosswise, 97.

............, DECIDUOUS. Falling off after the bursting of the anthers, 98.

............, FUGACIOUS. Falling off immediately after expansion, 98.

............, GAMOPETALOUS. Of one piece, or having its petals united, 93.

............, INFUNDIBULIFORM. Funnel-shaped, 94.

............, MARCESCENT. Remaining in a withered state, 98.

............, MASKED. Two-lipped, with the throat closed, 93.

............, MONOPETALOUS. Of one piece, 93.

............, PAPILIONACEOUS. Of five petals, and fancifully likened to a butterfly with expanded wings, 97.

............, PERSONATE. Monopetalous, with two lips, and the throat closed, 95.

............, POLYPETALOUS. Of several petals, 93, 95.

............, RINGENT. Monopetalous, with two lips, and the throat open, 94.

............, ROSACEOUS. Of five roundish spreading petals, 97.

............, ROTATE. With the tube short, the limb spread out flat, 94.

............, SALVER-SHAPED. With the tube long and narrow, the limb spread out flat, 94.

............, SPURRED. Having a hollow prolongation at the base, 95.

............, STRAP-SHAPED. Long, flat, with a short tube, 95.

............, TUBULAR. Narrow, cylindrical, and elongated, 94.

............, URCEOLATE. Globular or egg-shaped, with the mouth contracted, 94.

CORYMB. A raceme, the lower flowers of which have longer stalks than the upper, 81.

COTYLEDONARY BODY. A part of the seed separate from the embryo, and ultimately becoming a leaf, or leaves, 124.

COTYLEDONS, ACCUMBENT. Folded, with their edges to the radicle, 125.

................, INCUMBENT. Folded, with their back to the radicle, 125.

COTYLEDON. Parts of the seed which, after germinating, become seminal leaves, 124.

COWL-SHAPED. Having the form of a hood, 96.

CREEPING STEM. Lying along the ground, and sending down roots, 39.

CREEPING ROOT-STEM. A subterranean blended, elongated stem, nearly horizontal, with radicles at intervals, 34.

CRENATE LEAF. With the teeth regular, and not directed toward either end, 66.

CRISP LEAF. With the margin curled, 67.

CRUCIFORM COROLLA. Of four long-clawed petals, arranged in pairs, crosswise, 97.

CRYPTOGAMOUS PLANTS. Not furnished with flowers, 26.

CULM. The stem of a grass, generally simple, fistulous, and knotted, 36.

CUNEIFORM FILAMENT. Wedge-shaped, 102.

.... LEAF. Wedge-shaped, 62.

CUCULLIFORM. Having the form of a cowl or hood, 96.

CUPULA. Bracteas forming the cup of the acorn, 79.

CUP-SHAPED CALYX. Concave like a cup, 90.

CURVINERVED LEAVES. Having the fasciculi of vessels unbranched and curved, 60.

CUSPIDES OR THORNS. Indurated and pointed twigs, 42.

CUTICLE. The delicate membrane which covers all the parts of a plant, 18.

CYATHIFORM. Cup-shaped, 114.

CYLINDRICAL LEAF. Elongated and round, 68.

CYNARRHODIUM. Numerous dry ovaria within the fleshy tube of a calyx, 120.

DECANDROUS. Having ten stamens, 101.

DECIDUOUS COROLLA. Falling after the bursting of the anthers, 98.

DECIDUOUS LEAVES. Falling before next spring, 72.

DECLINATE STAMENS. Directed downwards, 101.

.... STYLE. Inclined downwards, 111.

DECOMPOSED LEAVES. Compound leaves subdivided, 70.

DECUSSATE LEAVES. In pairs, alternately crossing, 57.

DELTOID LEAF. With three angles, 63.

DEHISCENCE OF ANTHERS. Their mode of opening, 104.

DEHISCENT FRUITS. Opening when ripe in a definite manner, 118.

DEPRESSED LEAVES. Radical leaves pressed close to the ground, 57.

DIADELPHOUS. Having the filaments united into two parcels, 103.

DIANDROUS. Having two stamens, 106.

DIŒCIOUS PLANT. One individual having male flowers only, another individual of the same species having female flowers only, 100.

DICHOTOMOUS STEM. Regularly dividing into two, 38.

DICOTYLEDONOUS PLANTS. Of which the seeds have two cotyledons, 24.

DIDYMOUS ANTHERS. Of two spheroidal lobes, 104.

.... TUBERS. Oblong and in pairs, 31.

DIDYNAMOUS. With two long and two short stamens, 101.

DIFFUSE STEM. Loosely spreading, 39.

DIGITATE LEAF. Of several leaflets proceeding from the tip of the petiole, 69.

.... TUBERS. Resembling fingers, 31.

DIPETALOUS. Of two petals, 96.

DISTRACTILE CONNECTIVE. Forked, 103.

DISCOID STIGMA. Flat and round, 112.

DISK. A fleshy or glandular body between the stamens and ovary, 114.

DISSEPIMENTS. Partitions, or walls of the cells, in ovaries and fruits, 109, 117.

DISTICHOUS LEAVES. Spreading two ways, 57.

DIVERGENT BRANCHES. Coming off at an angle of about forty degrees, 53.

DODECANDROUS. Having twelve stamens, 101.

DOTTED DUCTS. Having the fibre broken into small fragments, 16.

DOTTED STEM. Covered with numerous somewhat prominent dots, 41.

DOUBLE PERIANTH. Consisting of calyx and corolla, 88.

DOWNY. Covered with short, delicate, flexile hairs, 20.

DRUPE. A fruit with a thick fleshy mesocarp, and hard endocarp, 119.

DUCTS. Vessels destitute of spiral fibres, 16.

........., ANNULAR. Having rings at intervals, 16.

........., DOTTED. In which the spiral fibre is broken into small fragments, 16.

........., RETICULATED. Having the fibre branched, 16.

ELEMENTARY ORGANS OR PARTS. The ultimate structural elements of plants, 9.

ELLIPTICAL LEAF. Elongated with both ends rounded and equal, 62.

EMARGINATE LEAF. With a small notch at the end, 65.

EMBRYO. The essential part of the seed, 123.

EMERSED LEAVES. Rising out of the water, 58.

ENDOCARP. Inner layer of the pericarp, 116.

ENDORHIZOUS PLANTS. Of which the seeds have the radicle covered by a sheath, 124.

ENNEANDROUS. Having nine stamens, 101.

ENSIFORM LEAF. Laterally flattened and erect, 68.

ENTIRE CALYX. Without any division or teeth, 89.

.... LEAF. With the margin continuous, 66.

EPICARP. Outer layer of the pericarp, 116.

EPIDERMIS OR CUTICLE. The delicate membrane which invests all the organs, 18, 25, 45.

EPIPODIUM. A disk formed of several knobs or glands, 114.

EPIGEAL COTYLEDONS. Rising to the surface, 125.

EPIGYNOUS INSERTION. On the summit of the ovary, 106, 114.

EPIPHYLLOUS PEDUNCLE. Arising from the surface of a leaf, 77.

EQUITANT. Alternately overlapping at the base, and rising obliquely, 74.

ERECT LEAVES. Forming a very acute angle with the stem, so as to be nearly upright, 57.

.... STAMENS. Parallel to the axis of the flower, 101.

.... STEM. Growing upright, 38.

.... STIGMA. In the axis of the flower, 112.

ETERIO. A fruit composed of numerous indehiscent ovaria, on a dry or fleshy receptacle, 120.

EVEN STEM. Destitute of roughness, 41.

EXTRA-AXILLAR. From beside a leaf, 77.

EXORHIZOUS PLANTS. Of which the seeds have the radicle exposed, 124.

EXTRORSE ANTHER. Having its face directed outwards, 104.

FASCICULATE LEAVES. Several from the same point, 57.

.... TUBERS. Composed of a bundle of fleshy bodies, 32.

FERTILE FLOWER. Having pistils, 100.

FIBRE. Elongated, slender, filamentary substance, 11.

FIBROUS CELLULAR TISSUE. Of which the cellules are partially composed of fibre, 13.

.... ROOT. Composed of fibres or filaments, branched or simple, 29, 31.

FIG. A fleshy hollow receptacle, with numerous dry pericarps, 121.

FILAMENT. The stalk supporting an anther, 102.

............., CAPILLARY. Slender like a hair, 102.

............., CLAVATE. Club-shaped, 102.

............., CUNEIFORM. Wedge-shaped, 102.

............., FILIFORM. Like a thread, 102.

............., PETALOID. Expanded so as to resemble a petal, 102.

FILIFORM FILAMENTS OR STYLE. Slender like a thread, 102, 111.

FINGERED LEAF. Of several leaflets proceeding from the top of the petiole, 69.

-STULOUS LEAF. Cylindrical and hollow, 63.

FISTULOUS STEM. Having an internal cavity, 37.
FLAT LEAF. Expanded and thin, 66, 68.
FLESHY LEAF. Thick and juicy, 67.
FLEXILE STEM. Easily bent without breaking, 38.
FLEXUOUS STEM. Forming angles, 39.
FLOATING LEAVES. Lying on the surface of the water, 57.
FLORAL LEAVES. Bracteas or modified leaves placed at the base of the flowers, 56, 78.
FLOWER. The parts especially subservient to the reproduction of seeds, namely the perianth, stamens, and pistils, 84.
FLOWERLESS PLANTS. Agamous or cryptogamous, 127.
FLOWER-BUDS. Giving rise to flowers, 52, 85.
FLOWER, FERTILE, OR FEMALE. Having pistils, 100.
..........., HERMAPHRODITE. With stamens and pistils, 100.
..........., MALE. Having stamens only, 100.
..........., PEDUNCULATE. Stalked, 77.
..........., PERFECT. Having stamens and pistils, 100.
..........., RECEPTACLE OF THE. Summit of the peduncle, 85.
..........., SESSILE. Without peduncle, 76.
..........., STERILE. Having stamens only, 100.
FOLLICLE. A dry pericarp having the appearance of a folded leaf, 119.
FORKED STEM. Regularly and repeatedly dividing into two, 38.
FOUR-RANKED STEM. With the branches spreading in four directions.
FOUR-SIDED STEM. Having four sides and angles, 40.
FOVILLA. Granules in the grains of pollen, 105.
FREE OVARY. Not adherent to the calyx, 109.
.... PLACENTA. In the middle of the ovary, 110.
FRINGED LEAF. Margined with soft parallel hairs, 66.
FRONDS. The leaves of ferns, 127.
FRUIT. The mature ovary, 116.
FRUITS, AGGREGATED. Formed of several series of simple ovaria, 119.
.........., COLLECTIVE. Having the floral envelopes or bracteas enlarged and thickened, 121.

FRUITS, COMPOUND. Of several united ovaria, 120.

........., SIMPLE. Formed of a single series of simple ovaria, 120.

FUGACIOUS COROLLA. Falling immediately after its expansion, 98.

FULL STEM. Filled with pithy matter, 37.

FUNNEL-SHAPED COROLLA. With the tube gradually dilating, and the limb preserving the same direction, 94.

FUNICULUS. Stalk of the ovule, 110.

FURROWED STEM. With longitudinal ridges and grooves, 42.

FUSIFORM ROOT. Tapering toward both ends, 31.

GAMOPETALOUS CALYX or COROLLA. Of one piece, 93, 89.

GEMINATE LEAVES. In pairs, 56.

GEMMULE. Top of the young stem in the germinating seed, 124.

GENICULATE STEM. With the joints angularly bent, 40.

GLANDS. Small dense prominences in the tissue, causing the cuticle to project, 21.

GLANDULA. A small gland, 21.

GLAUCOUS. Covered with powder of a sea-green colour, 41.

GLOBULAR TUBERS. Round like a ball, 31.

GLUMES. Bracteas of grasses, 80.

GONOPHOSE. Columnar receptacle elevating the stamens, 114.

GOURD. A one-celled, indehiscent, fleshy fruit, with numerous seeds attached to pulpy placentæ, 121.

GRANULIFEROUS ROOT. Fibrous with numerous small knobs, or fleshy buds, 31.

GROOVED STEMS. With longitudinal ridges and grooves, 42.

GYNANDROUS. Having the stamens and pistil united, 100.

GYNOBASE. Enlarged disk, 114.

GYNOPHORE. Columnar receptacle bearing the fruit, 114.

HAIRS. Elongations of cellular tissue on the surface of organs, 19.

HASTATE LEAF. Triangular, with two spreading lobes at the base, 63.

HATCHET-SHAPED LEAF. Somewhat like an axe-head, 68.

HELMET-SHAPED. Vaulted and hollow, like a helmet, 96.

HEMISPHERICAL STIGMA. Like the half of a sphere, 112.

HEPTANDROUS. Having seven stamens, 101.

HERBACEOUS ENVELOPE. Parenchymatous tissue under the cuticle, 46.

HERMAPHRODITE FLOWERS. Having stamens and pistils, 100.

HESPERIDIUM. A fleshy fruit with a thick envelope, and pulpy interior divided by longitudinal membranous dissepiments, 121.

HEXANDROUS. Having six stamens, 101.

HEXAPETALOUS. Of six petals, 96.

HILUM. Point of attachment of the umbilical cord or podosperm, 122.

HIRSUTE. Covered with rather long stiffish hairs, 20.

HISPID. With conical, long, stiff hairs, 20.

HORIZONTAL LEAVES. Spreading at right angles, 57.

.... ROOT. Running horizontally, 32.

HYPOGEAL COTYLEDONS. Remaining under ground, 125.

HYPOGYNOUS INSERTION. Beneath the ovary, 106, 114.

IMBRICATE ÆSTIVATION. When the petals cover each other laterally, 86.

.... LEAVES. Lying over each other like tiles, 57, 74.

IMPARI-PINNATE LEAF. Terminated by a leaflet, 70.

INCLUDED STYLE. Not projecting beyond the mouth of the flower, 111.

INCUMBENT COTYLEDONS. Folded with their back to the radicle, 125.

INCURVED LEAVES. Curved inwards, 57.

INDUSIUM. Cover of the sori of ferns, 128.

INFERIOR FLOWERS. Placed below the ovary.

.... OVARY. Placed below the perianth, 109.

INFLATED COROLLA OR CALYX. Thin, and as if blown out like a bladder, 90, 95.

INFLECTED PETALS. Curved inwards, 96.

.... STAMENS. Curved toward the centre of the flower, 101.

INFLORESCENCE. The manner in which the flowers are disposed upon the stem or peduncle, 76.
INORGANIC. Not possessed of organs, 1.
INNATE ANTHER. Attached by the base, 104.
INNER BARK. The liber, or innermost layer of bark, 46.
IRREGULAR CALYX OR COROLLA. Having the divisions of the limb unequal, 90, 94.
INSERTION, EPIGYNOUS. On the summit of the ovary, 106.
............., HYPOGYNOUS. Beneath the ovary, 106.
............., PERIGYNOUS. Upon the calyx, at a distance from the axis, 106.
INTERCELLULAR PASSAGES. Vacuities existing between the cellules, 12.
INTRORSE ANTHER. FACING the axis, 104.
INVOLUCEL. Bracteas at the base of an umbellule, 79.
INVOLUCRE. Numerous bracteas disposed round flowers, 79.
.... Bracteas at the base of an umbel, 79.
.... Covering of the sori of ferns, 128.
INVOLUTE. Rolled forwards or inwards, 74.

JAGGED LEAF. With the margin irregularly notched, 66.
JOINTED STEM. Having the appearance of joints, or contractions, at intervals, 40.

KEEL. The two lower petals of a papilionaceous corolla, 97.
KERNEL. Part of the seed within the perisperm, 123.
KNOTTED STEM. Having knots or sudden enlargements at intervals, 40.
KIDNEY-SHAPED LEAF. Broader than long, with a wide sinus at the base, 65.

LABIATE COROLLA. Monopetalous, with two lips, and the throat open, 94.
LACINIATE LEAF. Deeply cut into numerous irregular portions, 64.
LAMINA. The expanded part of a petal, 93.
LAMINÆ. Plates of the hymenium in mushrooms, 130.
LANCEOLATE LEAF. Oblong and tapering at both ends, 62.
LATERAL STIGMA. At the side of the style, 112.

LATERAL STYLE. From the side of the ovary, 111.
LEAF. An expanded organ, composed of cellular tissue, traversed by vessels, and covered with epidermis, 55.
......, ACUMINATE. Taper-pointed, 65.
......, ACUTE. Sharp-pointed, 65.
......, AMPLEXICAUL. Embracing the stem all round, 59.
......, ARTICULATED. Of which the petiole is contracted at the base, 68.
......, AWL-SHAPED. Elongated conical, 68.
......, BIFID. Slit to a small extent, 65.
......, BIJUGATE. With two pairs of leaflets, 70.
......, BINATE. With two leaflets, 70.
......, BIPARTITE. Slit to a considerable extent, 65.
......, BIPINNATE. Twice pinnate, 71.
......, BIPINNATIFID. Pinnatifid, with the segments similarly divided, 64.
......, BITERNATE. Twice ternate, 71.
......, BLISTERY. Much wrinkled, 67.
......, CANALICULATE. With a longitudinal groove above, 67.
......, CARINATE. With a longitudinal ridge beneath, 67.
......, CHANNELLED. With a longitudinal groove above, 67.
......, CIRROSE. Terminated by a tendril, 65.
......, CLEFT. With narrow clefts, 64.
......, CONICAL. Having the form of a cone, 68.
......, COMPOUND. Of several distinct pieces or leaflets, 59.
......, COMPRESSED. Laterally flattened, 68.
......, CONCAVE. With the upper surface concave, 67.
......, CONJUGATE. With one pair of leaflets, 70.
......, CONVEX. Having its upper surface convex, 66.
......, CORDATE. Heart-shaped, 63.
......, CORIACEOUS. Thick and dense, 67.
......, CRENATE. With the teeth regular, and not directed toward either end, 66.
......, CRISP. With the margin curled, 67.
......, CYLINDRICAL. Elongated and round, 68.
......, DELTOID. With three angles, 63.
......, DIGITATE. Of several leaflets proceeding from the tip of the petiole, 69.

LEAF, ELLIPTICAL. Elongated, with both ends rounded and equal, 62.

......, EMARGINATE. With a small notch at the end, 65.

......, ENSIFORM. Laterally flattened, and erect, 68.

......, ENTIRE. With the margin continuous, 66.

......, FINGERED. Of several leaflets proceeding from the top of the petiole, 69.

......, FISTULOUS. Cylindrical and hollow, 68.

......, FRINGED. Margined with soft parallel hairs, 66.

......, FLAT. Expanded, 66, 68.

......, FLESHY. Thick and juicy, 67.

......, HASTATE. Triangular, with two spreading lobes at the base, 63.

......, HATCHET-SHAPED. Somewhat like an axe-head, 68.

......, JAGGED. With the margin irregularly notched, 66.

......, LACINIATE. Deeply cut into numerous irregular portions, 64.

......, LANCEOLATE. Oblong, and tapering to either end, 62.

......, LINEAR. Narrow, with the sides parallel, 62.

......, LINGULATE. Thick, oblong, and obtuse, 68.

......, LOBED. With the divisions deep and rounded, 64.

......, LUNULATE. Crescent-shaped, 63.

......, LYRATE. Sinuate, with the terminal lobe largest, 64.

......, MEMBRANOUS. Very thin and pliant, 67.

......, MUCRONATE. Tipped with a stiff spine, 65.

......, NEEDLE-SHAPED. Linear, pointed, and stiff, 62.

......, OBCORDATE. Inversely heart-shaped, 65.

......, OBLONG. Several times longer than broad, 62.

......, OBOVATE. Ovate, with the broad end outermost, 62.

......, OBTUSE. Blunt at the end, 65.

......, ORBICULAR. Of a circular form, 62.

......, OVATE. Of greater length than breadth, rounded at both ends, but broader at the base, 62.

......, OVIFORM. Of the form of an egg, 68.

......, PALMATE. Cut about half way into oblong segments, so as to resemble a hand, 64.

......, PANDURIFORM. Oblong, contracted in the middle, so as to resemble a fiddle, 63.

LEAF, PARTITE. Having the divisions extending a considerable way down, 64.

......, PECTINATE. Pinnatifid, with the segments very narrow and parallel, 64.

......, PEDATE. Of three leaflets, but with the two lateral subdivided, 70.

......, PELTATE. Round, with the petiole inserted in the centre, 59.

......, PERFOLIATE. Embracing the stem, and having the base united beyond it, 59.

......, PETIOLATE. Having a stalk, 58.

......, PINNATE. Compound, with leaflets on either side of the stalk, 70.

......, PINNATIFID. Simple, with oblong, lateral, obtuse segments, 64.

......, PLAITED. Having the limb acutely folded, 67.

......, PREMORSE. Very blunt, with irregular notches, 65.

......, QUADRANGULAR. With four angles, 62.

......, QUADRIJUGATE. With four pairs of leaflets, 70.

......, QUATERNATE. Of four leaflets, 70.

......, QUINQUANGULAR. With five angles, 62.

......, RENIFORM. Kidney-shaped, 65.

......, REPAND. Having the margins waved, 66.

......, RHOMBOID. Diamond-shaped, 63.

......, RIBBED. Having longitudinal unbranched vessels, 71.

......, ROUNDISH. Nearly circular, 62.

......, RUNCINATE. With acute lateral segments pointing backwards, 64.

......, RUGOUS. Wrinkled, 67.

......, SAGITTATE. Triangular, with the lower angles prolonged and acute, 63.

......, SCARIOUS. Very thin and dry, 67.

......, SCIMITAR-SHAPED. With one edge thick and straight, the other thin and curved, 68.

......, SEMIAMPLEXICAUL. Half way embracing the stem, 58.

......, SEMICYLINDRICAL. Elongated, flat on one side, round on the other, 68.

LEAF, SERRATE. With the teeth sharp, and directed toward the tip, 66.

......, SHEATHING. Forming a sheath to the stem, 59.

......, SIMPLE. Of which the limb consists of a single piece, 59.

......, SINUATE. With rounded projections and sinuses, 63.

......, SOFT. Soft and easily bent, 67.

......, SPATHULATE. Oblong, with the outer end enlarged, 62.

......, SPINOUS. Having the margin beset with spines, 66.

......, STIFF. Hard, and not easily bent, 67.

......, SWORD-SHAPED. Laterally flattened and erect, 68.

......, TERNATE. Of three leaflets, 69.

......, TETRAGONAL. Four-edged, 68.

......, TONGUE-SHAPED. Thick, oblong, and obtuse, 68.

......, TOOTHED. Beset with small teeth, 66.

......, TRIANGULAR. With three prominent angles, 62.

......, TRIJUGATE. With three pairs of leaflets, 70.

......, TRUNCATE. Abruptly terminated, 65.

......, TRIPINNATE. Thrice pinnate, 71.

......, TRIQUETROUS. Having three longitudinal edges, 68.

......, TRITERNATE. Thrice ternate, 71.

......, TUBULAR. Cylindrical and hollow, 68.

......, UNDULATED. Having the limb waved, 67.

......, UNIJUGATE. With one pair of leaflets, 70.

......, VEINLESS. Without prominent vessels, 71.

......, VEINY. With the vessels prominent and branched, 71.

......, WEDGE-SHAPED. Broad at the end, and tapering toward the base, 62.

LEAF-BUDS. Giving rise to leaves, 52.

LEAFY BUDS. Of which the scales are imperfect leaves, 51.

.... STEM. Covered with leaves, 40.

LEAVES, ADPRESSED. Pressed close to the stem, 57.

........., ALTERNATE. Coming off one by one, 56.

........., ANGULINERVED. With branched nerves, 61.

........., CADUCOUS. Falling before next spring, 72.

........., CAULINE. Attached to the stem, 56.

........., COMPOUND. Formed of several distinct pieces, 69.

........., CONNATE. United by their bases, 59.

LEAVES, CURVINERVED. With curved unbranched nerves, 60.
........., DECOMPOUND. Twice subdivided, 71.
........., DECUSSATE. In pairs alternately crossing, 57.
........., DEPRESSED. Radical leaves pressed close to the ground, 57.
........., DISTICHOUS. Spreading two ways, 57.
........., EMERSED. Rising out of the water, 58.
........., ERECT. Forming a very acute angle with the stem, 57.
........., FASCICULATE. Several from the same point, 57.
........., FLOATING. Lying on the surface of the water, 57.
........., FLORAL. Placed at the base of the flowers, 56.
........., GEMINATE. In pairs, 56.
........., HORIZONTAL. Spreading at right angles, 57.
........., IMBRICATED. So close as to lie over each other, 57.
........., INCURVED. Curved inward, 57.
........., MARCESCENT. Withering before they fall, 72.
........., OPPOSITE. In pairs opposite to each other, 56.
........., PALMINERVED. With the nerves diverging from the top of the petiole, 61.
........., PEDATINERVED. With three nerves, of which the lateral are branched, 61.
........., PENDENT. Directed downwards, 57.
........., PENNINERVED. With a midrib branched on either side, 61.
........., PERSISTENT. Remaining all winter, 72.
........., PRIMORDIAL. Those which come first after the cotyledons, 56.
........., RADICAL. Those which spring from the neck of the root, 56.
........., RAMEAL. Attached to the branches, 56.
........., RECLINATE. Inclining downwards, 57.
........., RECURVED. Curved backwards, 57.
........., REVERSED. With the lower surface turned upwards, 57.
........., SCATTERED. Dispersed without order, 56.
........., SEMINAL. Those formed of the cotyledons, 56.
........., SESSILE. Without petiole, 58.
........., SPREADING. Forming a moderately acute angle, 57.

LEAVES, SUBMERSED. Covered by the water, 58.

........., UNILATERAL. Leaning toward one side, 57.

........., VERTICAL. Perpendicular, 57.

........., VERTICILLATE. Three or more growing in a circle round the stem, 56.

LEGUME. A pericarp formed of a single carpel folded upon itself, and separated into two valves, 119.

LEPIS. A thin flat membranous process or scale, 21.

LENTICELS. Small glands on the epidermis, 45.

LEPICENES. Outer branches of grasses, 80.

LIBER. Inner layers of bark, 46.

LIMB. The expanded part of the calyx, corolla, petal, or leaf, 55, 59, 93, 94.

LINEAR LEAF. Narrow, with the sides parallel, 62.

LINGULATE LEAF. Thick, oblong, and obtuse, 68.

LIPPED COROLLA. Monopetalous, with two lips, 94.

LOBED LEAF. With the divisions deep and rounded, 64.

.... STIGMA. Of several rounded segments, 112.

LOBIFEROUS ROOT. Fibrous, with amylaceous tubers, 30.

LOCULICIDAL. Opening in the middle of the carpels, 118.

LUNULATE LEAF. Crescent-shaped, 63.

LYRATE LEAF. Sinuate, with the terminal lobe largest, 64.

LYRATELY-PINNATE LEAF. Having the terminal leaflet much larger, 70.

MALE FLOWER. Having stamens only, 100.

MARCESCENT COROLLA. Remaining long in a withered state, 98.

.... LEAVES. Withering before they fall, 72.

MASKED COROLLA. Two-lipped, with the throat closed, 95.

MEDIIFIXED ANTHER. Attached by the back, 103.

MEDULLARY RAYS. Thin vertical plates of cellular tissue radiating from the axis, 25, 48.

.... SHEATH. The envelope of the pith, 25, 48.

MEMBRANE. A thin, colourless, transparent, tenacious substance, 11.

MEMBRANOUS CELLULAR TISSUE. Of which the cellules are membranous, 13.

.... LEAF. Thin and pliant, 67.

MESOCARP. Middle part or layer of the pericarp, 116.
MIXED BUDS. Giving rise to leaves and flowers, 52.
MONADELPHOUS. Having the filaments united into a tube, 103.
MONANDROUS. Having one stamen, 101.
MONOCOTYLEDONOUS PLANTS. Those of which the seeds have a single cotyledon, 25.
MONŒCIOUS PLANT. Having male flowers and female flowers on the same individual, 100.
MONOPETALOUS COROLLA. Undivided, of one piece, 93.
MONOSEPALOUS CALYX. Undivided, of one piece, 89.
MOTILITY. Capability of motion, 7.
MUCRONATE LEAF. Tipped with a stiff spine, 65.
MULTILOCULAR. Of many cells, 117.

NAKED OVULES. Without covering, 110.
.... STEM. Without leaves, 40.
NERVATION OF LEAVES. The distribution of their nerves or veins, 60.
NECK OF THE ROOT. The part by which it unites with the stem or leaves, 27.
NECTARIES. Organs secreting or containing a sweet fluid, 114.
NEEDLE-SHAPED LEAF. Linear, pointed, and stiff, 62.
NODOSE STEM. With knots at intervals, 40.
NUCLEUS. The part of the seed within the perisperm, 123.
.... Central part of the ovule, 110.
NUCULA. A hard indehiscent pericarp containing a single seed, 119.

OBCORDATE LEAF. Inversely heart-shaped, 65.
OBLIQUE ROOT. Running obliquely, 32.
.... STIGMA. Directed to one side, 112.
OBLONG LEAF. Several times longer than broad, 31.
.... TUBERS. Longer than broad, 31.
OBOVATE LEAF, SEPAL, OR PETAL. Ovate, with the broad end outermost, 62.

OBTUSE LEAF, SEPAL, OR PETAL. Blunt, 65.

OBVOLUTE. Two folded leaves clasping each other, 74.

OCTANDROUS. Having eight stamens, 101.

OMPHALODE. Central part of the hilum, 123.

OPERCULUM. Lid of the capsule in mosses, 129.

OPPOSITE LEAVES. In pairs, and placed opposite to each other, 56.

.... PETALS. Opposite the sepals, 98.

OPPOSITELY-PINNATE LEAF. With the leaflets opposite, 70.

ORBICULAR LEAF. Of a circular form, 62.

ORGANIC BODIES. Composed of organs, 1.

.... TISSUE. The elementary organs, 9.

ORGANOGRAPHY. Vegetable anatomy, 3.

ORGANS OF PLANTS. The distinct parts of which they are composed, 9.

........., COMPOUND. Those composed of the elementary tissues, 22.

........., NUTRITIVE OR CONSERVATIVE. Those by which the function of nutrition is performed: the root, stem, and leaves, 10.

........., PERFECTED. The root, stem, leaves, flowers, and fruit, 23.

........., REPRODUCTIVE. Those by which the function of reproduction is performed: the flower and fruit, 10.

........., RUDIMENTARY. Those developed in the seed when germinating, 23.

OVARIES. The lower part of the pistil containing the seeds in their rudimentary state, 108.

............, PARIETAL. Placed on the inner walls of a tubular calyx, 109.

............, INFERIOR. Below the perianth, 109.

............, FREE. Not adherent to the calyx, 109.

............, SUPERIOR. Above the perianth, 109.

OVARY. Lower part of the pistil containing the ovules, 108.

........., DISSEPIMENTS OF THE. Its partitions, 109.

OVATE LEAF. Of greater length than breadth, and rounded at both ends, 62.

OVIFORM LEAF. Of the form of an egg, 68.

OVULE, NAKED. Destitute of covering, 110, 181.

OVULES. Young seeds, 110, 181.

.........., ANATROPOUS. Having their position reversed, 183.

.........., CAMPULITROPOUS. Curved or bent, 183.

.........., ORTHOTROPOUS. Direct and straight, 183.

PALEÆ. Inner bracteas of grasses, 80.

PALEOLÆ. Minute scales at the base of the ovary in grasses, 80.

PALMATE TUBERS. Shaped like the hand, 31.

.... LEAF. Cut about half way into oblong segments, so as to resemble a hand, 64.

PALMINERVED LEAVES. With the nerves diverging from the tip of the petals, 61.

PANDURIFORM LEAF. Oblong, contracted in the middle, 63.

PAPILIONACEOUS COROLLA. Of five petals, of which one is large, the two lateral equal, the two lower united, 67.

PAPILLATE STEM. Covered with soft tubercles, 51.

PAPPUS. A modification of the calyx in the Compositæ, in which it assumes the form of numerous filaments, 91.

.........., FEATHERY. Having the filaments feathery, 92.

.........., PILOSE. Of simple filaments, 92.

.........., PLUMOSE. Having the filaments feathery, 92.

.........., STIPITATE. Elevated on a stalk, 92.

PARIETAL OVARIES. Disposed on the inner walls of a tubular calyx, 109.

.... PLACENTA. Not projecting far toward the interior of the capsule, 108.

PARTITE CALYX. With divisions reaching nearly to the base, 90.

.... LEAF. Having the divisions extending a considerable way down, 64.

PECTINATE LEAF. Pinnatifid, with the segments very narrow and parallel, 64.

PEDATE LEAF. Of three leaflets, but with the two lateral subdivided, 70.

PEDATINERVED LEAVES. With three nerves, of which the lateral are branched, 61.

PEDICELS. Divisions of the peduncle, 76.

PEDUNCLE. Stalk of a flower, 76.

............., CAULINE. Springing from the stem, 77.

............., EPIPHYLLOUS. From the surface of a leaf, 77.

............., RADICAL. From the axil of a radical leaf, 77.

PEDUNCULATE FLOWER. Furnished with a stalk, 77.

PELTATE LEAF. Round, with the petiole inserted in the middle, 59.

PELTINERVED LEAVES. With nerves radiating all round, 61.

PENDULOUS STAMENS. Slender and hanging, 101.

PENDENT LEAVES. Directed downwards, 57.

PENNINERVED LEAVES. With a midrib branched on either side, 61.

PENTAGONAL OVARY. Five-sided, 109.

.... STEM. Five-sided, 109.

PENTANDROUS. Having five stamens, 101.

PENTAPETALOUS. Having five petals, 96.

PENTASEPALOUS. Having five sepals,

PERFECTED ORGANS. The root, stem, leaves, flowers, and fruit, 23.

PERFECT FLOWER. Having stamens and pistils, 100.

PERFOLIATE LEAF. Embracing the stem, and expanded and united at the base, 59.

PERIANTH. The floral envelope, the calyx and corolla, or either, 86.

............., SINGLE. Of one verticil, 88.

............., DOUBLE. Of both calyx and corolla, 88.

PERICARP. The part of the fruit which invests the seed or seeds, 116.

PERIGYNOUS INSERTION. Upon the calyx, at a distance from the axis, 106, 114.

PERISPERM. Covering of the seed, 123.

PERISTOME. Part surrounding the mouth of the capsule in mosses, 129.

PERSISTENT LEAVES. Remaining all winter, 72.

.... STYLE. Remaining after fecundation, 111.

PERSONATE COROLLA. Monopetalous, with two lips, and the throat closed, 95.

PETALOID FILAMENT or STYLE. Expanded and thick, so as to resemble a petal, 102, 111.

PETALS. Leaves of the corolla, 96.

........., ALTERNATE. Alternating with the sepals, 98.

........., CUCULLIFORM. Having the form of a cowl, 96.

........., ERECT. In the direction of the axis, 96.

........., INFLECTED. Curved inwards, 96.

........., REFLECTED. Curved outwards, 96.

........., SPREADING. At right angles to the axis, 96.

........., OPPOSITE. With reference to the sepals, 98.

........., VAULTED. Hollow like a helmet, 96.

PETIOLATE LEAF. Having a stalk, 58.

PETIOLAR BUDS. Of which the scales are formed by the persistent bases of the leaf-stalks, 51.

PETIOLE. The stalk of a leaf, 55.

..........., CHANNELLED. With a groove on its upper surface, 59.

..........., CLUB-SHAPED. Enlarged at its upper part, 59.

PHÆNOGAMOUS or PHANEROGAMOUS PLANTS. Furnished with flowers, 26.

PHYLLODIUM. A leaf-like petiole, 59.

PHYSIOLOGY, VEGETABLE. The functions of plants, 2, 3.

PHYTOLOGY. The science of plants, Botany, 1.

PHYTOTOMY. Vegetable anatomy, 2, 3.

PILEUS. Convex part of mushrooms, 130.

PILOSE. Covered with long, scattered, rather soft hairs, 20.

.... PAPPUS. Of simple hairs, 92.

PINNATE LEAF. Compound with lateral leaflets, 70.

PINNATIFID LEAF. With oblong, lateral, obtuse segments, 64.

PINNINERVED COMPOUND LEAVES. Having pinnate nerves, 70.

PISTIL. The central organ of the flower, 108.

........., SIMPLE. Formed of a single carpel, 108.

........., COMPOUND. Formed of several carpels, 108.

PITCHER. A modification of the leaf resembling a pitcher, 73.

PITH. The central cylinder of cellular tissue, 25.

PLACENTA. Bundle of vessels to which the ovules are attached, 108.

PLACENTA, FREE. In the middle of the ovary, 110.

............, PARIETAL. Not projecting far inwards, 108.

PLAITED ÆSTIVATION. When a monopetalous corolla is longitudinally folded upon itself, 86.

PLAITED LEAF. Having the leaf acutely folded, 67.

PLICATE. Folded lengthwise into plaits, 74.

PLUMULE. The part of the embryo that forms the stem and leaves, 124.

PODOGYNIUM. Columnar receptacle elevating the fruit, 114.

PODOSPERM. Stalk of the ovule, 110, 122.

POLLEN. Grains contained in the anther, 105.

POLYGAMOUS PLANT. Male flowers, female flowers, and fertile flowers, on one individual, or on separate individuals of the same species, 100.

POLYADELPHOUS. Having the filaments united into more than two sets, 103.

POLYANDROUS. Having many stamens, 101.

POLYPETALOUS. Of several petals, 93, 95.

POLYPHORE. Fleshy receptacle, with numerous ovaries, 114.

POLYSEPALOUS. Of several sepals, 91.

POWDERY STEM. Covered with a powdery substance, 41.

PRÆFLORATION. The manner in which the parts of the flower are arranged previous to expansion, 86.

PREMORSE LEAF. Very blunt, with irregular notches, 65.

.... or ABRUPT ROOT. Appearing as if cut off or eroded at the end, 29.

PRICKLES. Strong rigid hairs, of compound structure, 21.

PRIMINE. Outer coat of the ovule, 110.

PRIMORDIAL LEAVES. Those which come first after the cotyledons, 56.

PROCUMBENT STEM. Lying along the ground, but not quite flat, 39.

PROTRUDED STYLE. Projecting beyond the mouth of the flower, 111.

PROPER VESSELS. Such as contain peculiar secretions, 17.

PROSTRATE STEM. Lying flat on the ground, 38.

PUBESCENCE. The hairs considered in a general sense, 20.

Pubescent or **Downy**. Covered with short, delicate, flexile hairs, 20.

Puckered Æstivation. When the petals are folded in numerous small irregular plaits, 86.

Pyxidium. A dry pericarp, opening transversely, 121.

Quadrangular Leaf. With four angles, 62.

Quadrijugate Leaf. With four pairs of leaflets, 70.

Quadrilocular Anther or **Ovary**. Of four cells, 103, 117.

Quaternate Leaf. Of four leaflets, 69.

Quincuncial Æstivation. With the five petals covering each other in a particular way, 86.

Quinquangular Leaf. With five angles, 62.

Quinquelocular. Of five cells, 117.

Raceme. Pedicillate flowers on an unbranched elongated peduncle, 80.

Radical Leaves. Springing from the neck of the root, 56.

.... **Peduncle**. From the axil of a radical leaf, 77.

Radicle. Conical body forming part of the embryo, and becoming the root, 123.

Radicles. The fibres of the root, 27.

Rameal Leaves. Growing on the branches, 56.

Ramenta. Thin brownish scales, 21.

Raphe. Bundle of vessels proceeding from the hilum, 123, 182.

Receptacle. Summit of the peduncle, 85, 113.

Receptacles of Juices. Cavities containing secreted matters, 17.

Reclinate Leaves. Inclining downwards, 57.

Reclining Stem. Ascending at first, and then curved upwards, 39.

Recurved Leaves. Curved backwards, 57.

Reflected Petals. Curved outwards, 96.

.... **Stamens**. Bent outwards, 101.

Regular Calyx and **Corolla**. Having their parts equal, 90, 94.

Runcinate Leaf. With acute lateral segments pointing backwards, 64.

Reniform Leaf. Kidney-shaped, 63.

Repand Leaf. With the margin waved, 66.

Reservoirs of Juices. Containing the peculiar secretions, or juices, 17.

Reticulated Ducts. Those of which the fibre is branched, so as to resemble net-work, 16.

Retuse Leaf. Ending in a broad shallow notch, 65.

Reversed Leaves. With the lower surface turned upwards, 57.

Revolute. Rolled backwards at the sides, 74.

Rhizoma. A fleshy, subterranean stem, sending forth shoots at its upper end, and decaying at the other, 34.

Rhomboid Leaf. Diamond-shaped, 63.

Ribbed Leaf. Having longitudinal unbranched vessels, 71.

Ringent Corolla. Monopetalous, with two lips, and the throat open, 94.

Root. The descending portion of a plant, 27.

......, Abrupt or Premorse. Appearing as if cut off at the end, 29.

......, Branched. Dividing into branches, 31.

......, Bulbiferous. Fibrous, surmounted by a disk and bulb, 30.

......, Capillary. Of hair-like filaments, 31.

......, Comose. Of slender much-branched filaments, 31.

......, Conical. Of the form of a reversed cone, 31.

......, Fibrous. Composed of slender filaments, 29, 31.

......, Fusiform. Tapering toward both ends, 31.

......, Granuliferous. Fibrous, with numerous small bud-like knobs, 31.

......, Horizontal. Running horizontally, 32.

......, Lobiferous. Fibrous, with amylaceous tubers, 30.

......, Oblique. Running obliquely, 32.

......, Simple. Unbranched, 31.

......, Tapering. Fleshy and conical, 29.

......, Top-shaped. Globular and tapering, 31.

..., Tuberiferous. Fibrous, with tubers, 30.

, Vertical. Descending perpendicularly, 32.

ROOTSTOCK. A fleshy subterranean stem, sending forth shoots at its upper end, and decaying at the other, 34.

ROSACEOUS COROLLA. Of five roundish spreading petals, 97.

ROSTRUM. An elongated receptacle, with the styles adhering, 114.

ROTATE COROLLA. Monopetalous, with the tube short, the limb spreading out flat, 94.

RUDIMENTARY ORGANS. Those developed in the seed when germinating, 23.

RUGOUS LEAF. Wrinkled, 67.

RUNNER. A very slender prostrate stem, having a bud at the end, which sends out leaves and roots, 36.

SAGITTATE LEAF. Triangular, with the lower angles prolonged and acute, 63.

SALVER-SHAPED COROLLA. Monopetalous, with the tube long and narrow, the limb spread out flat, 94.

SAMARA. A two-celled, dry, indehiscent fruit, with membranous expansions, 120.

SARCOCARP. Fleshy middle part of the pericarp, 116.

SCABROUS. Rough, with small watery prominences, 22.

SCALES. Thin, flat, membranous processes, formed of cellular tissue, 21.

.... OF BUDS. Thin, concave, external plates, 52.

SCALY BULB. With the scales distinct, fleshy, and imbricated, 54.

.... STEM. Bearing scales instead of leaves, 41.

SCARIOUS. Very thin and dry, 67.

SCATTERED LEAVES. Dispersed without order, 56.

SCIMITAR-SHAPED LEAF. Like a sabre, 68.

SECONDINE. Inner coat of the ovule, 110.

SEED. The matured ovule, 122.

SEMIAMPLEXICAUL LEAF. Half embracing the stem, 58.

SEMICYLINDRICAL LEAF. Elongated, flat on one side, round on the other, 68.

SEMILIGNEOUS STEM. Woody at the base, herbaceous at the end, 37.

SEMINAL LEAVES. Those formed by the cotyledons, 56.

SEPALS. Leaves of the calyx, 89.

SEPTICIDAL. When the sutures correspond with the edges of the carpels, 118.

SERRATE LEAF. With the teeth sharp and directed toward the end, 66.

SESSILE FLOWER. Without peduncle, 78.

.... GLANDS. Not elevated on stalks, 22.

.... LEAF. Without petiole, 58.

.... STIGMA. Without style, 110, 112.

SETA. Stalk of the capsule in mosses, 129.

SHEATH of the pith, 48.

SHEATHING LEAF. Forming a sheath to the stem, 59.

SHINING STEM. Having the surface glossy, 41.

SILICULA. A short two-valved pericarp, with seeds attached to two lateral placentæ, 121.

SILIQUA. An elongated two-valved pericarp, with seeds attached to two lateral placentæ, 120.

SILKY. Covered with long, very slender, close-pressed, glistening hairs, 20.

SIMPLE FRUITS. Of which only one series is produced by each flower, 119.

.... LEAF. Of which the limb consists of a single piece, 59.

.... STEM and ROOT. Unbranched, 31, 38.

SINGLE PERIANTH. Of one verticil, 88.

SINUATE LEAF. With rounded projections and sinuses, 63.

SMOOTH STEM. Destitute of hairs, 41.

SOLID STEM. Destitute of internal cavity, 37.

SORI. Aggregated thecæ, 128.

SORIDIA. Masses of granular bodies, 130.

SPADIX. Elongated peduncle, covered with flowers, and inclosed with a spatha, 81.

SPATHA. A large membranous bractea, inclosing the flowers, 79.

SPATHULATE LEAF. Oblong, with the outer end enlarged, 62.

SPONGIOLES. Small cellular bodies, destitute of epidermis, terminating the radicles, 27.

SPONGY STEM. Internally composed of elastic cellular tissue, 37.

SPORULES. Reproductive organs of flowerless plants, 122, 128, 129.
SPIKE. Sessile flowers on an unbranched peduncle, 80.
SPIKELET. Small spikes of grasses, 80.
SPINE. An altered leaf, 73.
SPINOUS LEAF. Having the margins beset with spines, 66.
SPIRAL VESSELS. Such as are composed of spiral fibres, 15.
SPREADING BRANCHES. Coming off at a right angle, 53.
.... LEAVES. Forming a moderately acute angle, 57.
.... STAMENS. At right angles to the axis, 101.
SPURRED COROLLA. Having a hollow prolongation at the base, 95.
SQUAMOUS BULB. With the scales distinct, fleshy, and imbricated, 54.
SQUAMULÆ. Minute scales in the flower of a grass, 80.
SQUARE STEM. Having four sides, 40.
STALKED GLANDS Elevated on stalks, 22.
STAMENS. Fecundating organs, composed of an anther and pollen, 100.
............, ASCENDING. Directed upwards, 101.
............, DECLINATE. Directed downwards, 101.
............, ERECT. Parallel to the axis of the flower, 101.
............, INFLECTED. Curved toward the centre of the flower, 101.
............, PENDULOUS. Slender and hanging, 101.
............, REFLECTED. Bent outwards, 101.
............, SPREADING. At right anglos to the axis, 101.
STANDARD. The large petal of a papilionaceous corolla, 97.
STELLATE STIGMA. With radiating ridges, 112.
STERIL FLOWER. Having stamens only, 100.
STEM. The ascending axis with its appendages, 33, 35.
......., ALTERNATELY BRANCHED. With the branches coming off one after another, 38.
......., ANGULAR. With more than five angles, 40.
......., ASCENDING. Rising obliquely, 39.
......., BRITTLE. Stiff, but easily broken, 38.
......., CHINKY. With deep unequal chinks, 42.
......., CLIMBING. Ascending by tendrils, 39.

STEM, CLINGING. Adhering to another body by fibres, 39.
......., COMPRESSED. Flattened on opposite sides, 39.
......., CORKY. With the outer bark of the nature of cork, 42.
......., CREEPING. Lying along the ground, and sending down roots, 39.
......., DICHOTOMOUS. Regularly divided into two, 38.
......., DIFFUSE. Loosely spreading, 39.
......., DOTTED. Covered with numerous somewhat rounded dots, 41.
......., ERECT. Growing upright, 38.
......., EVEN. Destitute of roughness, 41.
......., FISTULOUS. Having an internal cavity, 37.
......., FLEXILE. Easily bent without breaking, 38.
......., FLEXUOUS. Bent so as to form angles alternately, 39.
......., FOUR-RANKED. With the branches spreading in four directions, 38.
......., FULL. Filled with pithy matter, 37.
......., FURROWED. With longitudinal ridges and grooves, 42.
......., GENICULATE. With the joints angularly bent, 40.
......., GLAUCOUS. Covered with a fine powder of a sea-green colour, 41.
......., HERBACEOUS. Of soft consistence, green, and lasting only one year, 36.
......., JOINTED. Having the appearance of joints at intervals, 40.
......., KNOTTED. With sudden enlargements at intervals, 40.
......., LEAFY. Covered with leaves, 40.
......., PAPILLATE. Covered with soft tubercles, 41.
......., PENTAGONAL. Five-sided, 40.
......., POWDERY. Covered with a powdery substance, 41.
......., PROCUMBENT. Lying along the ground, but not quite flat, 39.
.... PROSTRATE. Lying flat on the ground, 38.
......., RECLINING. Ascending at first, and then curved downwards, 89.
......., SCABROUS. Rough, with little harsh inequalities, 41.
......., SCALY. Bearing scales, 41.
......., SIMPLE. Destitute of branches, 38.

STEM, SHINING. Having the surface smooth and glossy, 41.
......., SMOOTH. Destitute of hairs, 41.
......., SOLID. Destitute of internal cavity, 37.
......., SPONGY. Internally composed of elastic cellular tissue, 37.
......., SPOTTED. Marked with spots of a different colour, 41.
......., SQUARE. Four-sided, 40.
......., STIFF. Rising directly, and firm enough to support itself, 37.
......., STRAIGHT. In a direct line, 39.
......., STRIATED. Marked with small longitudinal ridges and grooves, 47.
......., SUCCULENT. Internally spongy, or parenchymatous, and filled with fluid, 37.
......., SUFFRUTICOSE. Having the base hard and lasting several years, but the tip soft and annual, 37.
......., TETRAGONAL. Four-sided, 40.
......., THREE-EDGED. With three sharp angles, 40.
......., THREE-SIDED. With three flat sides, 40.
......., THREAD-LIKE. So slender as to resemble a thread, 40.
......., TORTUOUS. Angularly bent, 39.
......., TRAILING. Lying along the ground, 39.
......., TWINING. Spirally bent round another plant, 39.
......, TWO-RANKED. With the branches spreading in opposite directions, 38.
......., WAND-LIKE. Slender, long, straight, and tapering, 40.
......., WARTY. Presenting small roundish excrescences, 41.
......., WEAK. Unable to support itself, 37.
......., WHIP-LIKE. Long, slender, and supple, 40.
......., WINGED. With leafy borders, 41.
......., WOODY. Hard and of a woody nature, 37.
STIFF STEM. Rising directly, and firm enough to support itself, 37.
.... LEAF. Hard and not readily bent, 67.
STIGMA. The part of the pistil which receives the pollen, 112.
........., CAPITATE. Spherical or roundish, 112.
........., CAPILLARY. Hair-like, 112.
........., CLAVIFORM. Club-shaped, 112.

STIGMA, DISCOID. Flat and round, 112.

.........., ERECT. Upright, in the axis of the flower, 112.

.........., FILIFORM. Slender like a thread, 112.

.........., HEMISPHERICAL. Of the form of half a sphere, 112.

.........., LATERAL. At the side of the style, 112.

.........., LOBED. Of several rounded segments, 112.

.........., NAKED. Without leaves, 40.

.........., OBLIQUE. Directed to one side, 112.

.........., SESSILE. Without style, 110.

.........., STELLATE. Star-like, with diverging rays, 112.

.........., SUBULATE. Tapering to a point, 112.

........., TERMINAL. At the end of the style, 112.

STIPE. The woody stem of a monocotyledonous tree or fern, 35 ; also the stalk of a mushroom, 130.

STIPITATE PAPPUS. Supported on a stalk, 92.

STIPULAR BUDS. Enveloped by the stipules, 51.

STIPULE. A leaf-like appendage to the leaf, 72.

STOMATA. Apertures in the cuticle, generally bounded by two vesicles, 19.

STRAP-SHAPED COROLLA. Long, flat, and oblique, with a very short tube, 95.

STRIATED STEM. Marked with small longitudinal ridges and grooves, 41.

STYLOPODIUM. Epigynous disk of umbelliferæ, 114.

STYLE. Stalk of the stigma, 110.

........., ASCENDING. Curved upward, 111.

........., BASAL. From the base of the ovary, 111.

........., CADUCOUS. Falling after fecundation, 111.

........., CLAVIFORM. Club-shaped, 111.

........., DECLINATE. Inclined downwards, 111.

........., FILIFORM. Slender like a thread, 111.

........., INCLUDED. Not projecting beyond the mouth of the flower, 111.

........., LATERAL. From the side of the ovary, 111.

........., PETALOID. Expanded and thin, 111.

........., PERSISTENT. Remaining after fecundation, 111.

........., PROTRUDED. Projecting beyond the mouth of the flower, 111.

STYLE, SUBULATE. Tapering to a point, 111.
........., TRIGONAL. Three-cornered, 111.
........., VERTICAL. Upright, 111.
SUBMERSED LEAVES. Covered by the water, 58.
SUBULATE, LEAF, FILAMENT, STYLE, OR STIGMA. Round and tapering to a point, 102, 111, 112.
SUCCULENT STEM. Internally spongy and filled with fluid, 37.
SUCKER. A branch proceeding from the neck of the root, under ground, 36.
SUFFRUTICOSE STEM. Having the base hard, and lasting several years, but the tip soft and annual, 37.
SUPERIOR OVARY. Above the perianth, 109.
SUTURES. Seams of the pericarp, 118.
SWORD-SHAPED LEAF. Laterally flattened, and erect, 68.
SYNCARPOUS FRUIT. Having the carpels coherent, 117.
SYNORHIZOUS PLANTS. Of which the seeds have the radiclo incorporated with the endosperm, 124.

TAPERING ROOT. Fleshy and conical, 29.
TENDRIL. A filiform prolongation of the petiole, 73.
TERCINE. Innermost coat of the ovule, 110.
TERMINAL. At the tip of the stem or branch, 78.
.... STIGMA. At the end of the style, 112.
TERNATE LEAF. Of three leaflets, 69.
TETRADYNAMOUS. With four long and two short stamens, 101.
TETRAGONAL LEAF. Four-edged, 68.
.... OVARY. Four-sided, 109.
.... STEM. Four-sided, 40.
TETRANDROUS. Having four stamens, 101.
TETRAPETALOUS. Of four petals, 96.
TETRASEPALOUS. Of four sepals, 91.
THALAMUS. Receptacle of the fruit, 114.
THALLUS. Expanded part of lichens, 130.
THECAPHORE. Columnar receptacle, elevating the fruit, 114.
THORNS. Abortive and indurated twigs, 42.
THECÆ. Capsules of ferns, mosses, &c., 128, 129.
THROAT. Mouth of a monopetalous corolla, 97.

TISSUE, ORGANIC. The intimate structure of plants, 9.

........., VASCULAR. Composed of vessels, or elongated tubes, 14.

TOOTHED CALYX. Having pointed projections on the margin of the limb, 90.

.... LEAF. Beset with small teeth, 66.

TOMENTOSE. Covered with longish, soft, entangled hairs, 20.

TONGUE-SHAPED LEAF. Thick, oblong, and obtuse, 68.

TOP-SHAPED ROOT. Globular and tapering, 31.

TORTUOUS STEM. Angularly bent, 39.

TORUS. The part on which the fruits are placed, 114.

TRACHEÆ. Spiral vessels, 15.

TRIANDROUS. Having three stamens, 101.

TRIANGULAR STEM. With three sharp angles, 40.

.... LEAF. With three angles, 62.

TRIGONAL OVARY, OR STYLE. Three-cornered, 109, 111.

TRIJUGATE LEAF. With three pairs of leaflets, 70.

TRILOCULAR. Of three cells, 117.

TRIPETALOUS. Of three petals, 96.

TRIPINNATE LEAF. A pinnate leaf divided three times, 71.

TRIQUETROUS LEAF. Having three longitudinal edges, 68.

TRITERNATE LEAF. A ternate leaf divided three times, 71.

TRUNCATE LEAF. As if cut off by a straight line, 65.

TRUNK. The woody stem of a dicotyledonous tree, 35.

TUBE. The narrow basal part of a monopetalous corolla or calyx, 93.

TUBERIFEROUS ROOT. Fibrous, with tubers, 30.

TUBER. Subterranean fleshy stem, with buds, 34.

TUBERS, DIDYMOUS. Oblong and in pairs, 31.

.........., DIGITATE. Resembling fingers, 31.

.........., FASCICULATE. Composed of a bundle of fleshy bodies, 32.

.........., GLOBULAR. Round like a ball, 31.

.........., OBLONG. Longer than broad, 31.

.........., PALMATE. Shaped like the hand, 31.

TUBULAR. Narrow, elongated, and hollow, 68, 94.

TUNICATED BULB. Covered with continuous layers, 53.

TURIO. Subterranean bud of a perennial herbaceous plant, 53.

TWIGS. Divisions of the branches, 42.

TWINING STEM. Spirally bent round another plant, 39.

TWISTED ÆSTIVATION. When the petals are spirally twisted, 86.

TWO-EDGED. Round, with two opposite edges, 39.

TWO-RANKED STEM. With the branches spreading in opposite directions, 38.

UNDULATED LEAF. With the limb waved, 67.

UMBILICAL CORD. Vessels going to the seed, 122.

UNGUIS. The lower narrow part of a petal, 93.

UNIJUGATE LEAF. With one pair of leaflets, 70.

UNILATERAL LEAVES. Leaning toward one side, 57.

UNILOCULAR. Having one cell or cavity, 103.

URCEOLATE. Pitcher-shaped, globular or egg-shaped, with the mouth narrowed, 94.

VAGINANT LEAF. Forming a sheath to the stem, 59.

VALVES. Pieces of which a pericarp is composed, 118.

VASCULAR TISSUE. Composed of vessels or elongated tubes, 14.

VEGETABLE. An organized body, destitute of sensibility and voluntary motion, 5.

VEINLESS LEAF. Without prominent vessels, 71.

VEINY LEAF. With the vessels prominent and branched, 71.

VELVETY. Covered with short, dense, soft hairs, 20.

VENATION. The distribution of the veins or nerves, 60.

VERNATION. The manner in which the leaves are folded in the bud, 73.

VERRUCÆ. Roundish glandules filled with opaque matter, 21.

VERSATILE ANTHERS. Attached by a single point so as to turn easily, 104.

VERTICAL ROOT, STEM, STYLE, OR LEAVES. Perpendicular, 32, 38, 57, 116.

VERTICIL. Flowers encircling the stem, 80.

VERTICILLATE LEAVES. Encircling the stem, 56.

VESSELS, SPIRAL. Composed of spiral fibres, 15.

VEXILLUM. The large petal of a papilionaceous corolla, 97.

Villous. Covered with long, straight, soft hairs, 20.
Volva. Covering of mushrooms, 130.

Wand-like. Slender, long, straight, and tapering, 40.
Warts. Roundish granules filled with opaque matter, 21.
Warty Stem. Presenting small roundish excrescences, 41.
Wedge-shaped Leaf. Broad at the end, and tapering toward the base, 62.
Wheel-shaped Corolla. Monopetalous, with the tube short, the limb spreading out flat, 94.
Whorl. Flowers encircling the stem, 80.
Whorled Leaves. Growing in a circle round the stem, 56.
Whorls of the Flower. The sepals, petals, stamens, and pistils, 86.
Wings. The two lateral petals of a papilionaceous corolla, 97.
Winged Petiole. Having leafy borders, 59.
..........., Stem. When the margins of the leaves run down the stem, forming leafy borders, 41.
Wood or Woody Body. The cylindrical mass of woody layers, 43, 47.
Woody Stem. Chiefly composed of woody fibres, 37.
Woody Tissue or Fibre. Composed of elongated cells or tubes of a woody nature, 13.

Zigzag Stem. Forming alternate angles, 39.

INDEX.

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